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Design and Construction.

The great variety of methods of construction described in this issue of The Engineering Record will bring home to the reader an appreciation of the present importance of designing many classes of civil engineering structures with as much regard to the way they are to be built as to the nature of the service they are to perform after their completion. While it does not often happen that the conditions of construction will have much influence in fixing the general outlines of an engineering undertaking like a dam or bridge, they will affect its details in many cases, and sometimes to a marked degree. For this reason it is highly desirable that the designing office should be familiar with the latest novelties in construction methods, for it is only by possessing such knowledge that the office force can plan structures giving the maximum return for the money invested in them. This knowledge is particularly useful in drafting specifications concerning the manner in which work shall be carried on, for the well-informed specification writer can often save a client considerable money by outlining alternative methods of construction. A notable instance of this was afforded by the specifications for the Detroit River tunnel of the New York Central lines, which outlined four methods of construction acceptable to the engineers. A review of these requirements was printed in this journal on Feb. 17.

Another feature of the articles in this issue which stands out prominently is the importance of the engineering contractor. This is no more conspicuous in the case of the Blackwell's Island bridge, a structure depending as much for its design on the Pennsylvania Steel Company as on the Bridge Department of the City of New York, than in many of the less conspicuous works described. This is a feature of engineering work which should allay the apprehension some people feel concerning the future of the hosts of young people emerging annually from the portals of technical schools. There is a demand for such young men among contractors, and it will be greater soon. Already there are many contractors who have a high position in their business who began their work as engineers, and it is interesting to observe that in any kind of contracting calling for more information than a knowledge of trades and the ability to handle men well, the engineer has already won recognition as an indispensable factor. This is not surprising when it is considered that a contractor with engineering knowledge is able to appreciate fully the technical reasons for minor details of the plans and is thus more inclined to help the designing engineer than is a contractor without such knowledge.

Now that engineering undertakings have assumed such large dimensions, the distinction between the office engineer and the field engineer is more marked than ever before. The demand for plans keeps the office staff busy, while the field work leaves the resident engineers little time for designing more than details of plant or methods of handling work. In this way the resident engineer is being trained along the lines which will make him a good engineer for a contractor's staff, and, if he has the business ability in him, a contractor-engineer himself. The old prejudice against contractors which once was shown so strongly in some engineering circles is disappearing rapidly before the indisputable fact that among contractors to-day are to be counted many of the best engineers of the country, men who do just as good designing work in laying out their plants and detailing their methods as do the office engineers whose plans and specifications are the basis of a contract.

The Height of Manufacturing Buildings

The height of manufacturing buildings is a problem in mill architecture concerning which there is a great diversity of practice, probably because very little study has ever been given to it. There is nobody better qualified to express an opinion on the subject than Mr. James H. Edwards, assistant chief engineer of the American Bridge Co., and The Engineering Record has accordingly invited him to discuss in its editorial pages this important feature of industrial plant design.

The height of a manufacturing building for a one-story structure is usually considered the distance from the ground floor to the lowest part of the overhead roof supports, while for structures more than one-story high it is the distance from finished floor to finished floor, the effective height being reduced by the thickness of the floor construction. Proper lighting, heating, ventilation, and the character of the product, together with its method of manufacture, are the factors determining the height of a factory building. Such a structure in its simplest form is a house to protect the workman and his tools from the variable conditions of the weather. From this simple type progression is made by various stages to the structure which is a great tool in itself, specially adapted to produce, with the machines it contains, the plant's output at a minimum cost.

For proper lighting, other considerations being neglected, and providing light is not obstructed by adjoining buildings, an ordinary shop building should have a clear height of about one-fourth of its width. This applies to buildings up to the limit of simple spans, or 100 ft. wide and less. On this basis a building 50 ft. wide should not be less than 12 ft. high, which should be the minimum for any building in a temperate climate. For structures in tropical countries the minimum should be 15 ft. A building 80 ft. wide should be 20 ft. high, and for 100 ft. width 25 ft. would be the height for single structures, proper lighting and ventilation only being considered.

The above observations have been made with one-story structures in mind, but they also apply to the upper story of buildings of more than one story. The height of the lower stories should be increased over the dimensions determined as desirable for a one-story structure used for the same purpose, with the lower story the highest. This increase in height is to obtain light, and the practice is to increase the story next to the top, say 2 ft., while the bottom story, to obtain equally good light, should be 4 ft. higher than the top story.

The heating of buildings in cold climates is a feature to be considered, and in some localities is a maintenance expense that assumes serious proportions. The greater the height of a building the more heat required, so from a financial standpoint it may be advisable to reduce to 18 ft. the height of a building 80 ft. wide and forego some of the advantages of better light obtained by a higher structure.

When a building is considered as a part of the mechanical equipment, the character of the product and its method of production should be the governing factors in determining the height. The framework may support the shafting and the trolley runways, or it may be arranged for traveling cranes. The proper disposition of these features is of vital importance.

If the building is to carry shafting supported from the girders or trusses overhead, a clear height of 14 to 16 ft. should be maintained. If trolleys for light work are operated on runway beams attached to overhead supports, 16 ft. is usually the minimum height, while for heavy work or handling large pieces, the trolley beams should be 20 to 24 ft. high.

When traveling cranes are installed, the height must be determined by the capacity of the cranes and the methods of handling the work required for the shop's product. The customary practice for ordinary work is to obtain a height of about 20 ft. under the crane, which means a height of building of 24 to 30 ft. This is the usual construction for machine shops and foundries. As the product to be handled increases in size and the cranes in capacity, the heights necessarily increase. Buildings designed for special purposes, such as erection shops for engines, pumps, and electrical machinery, are fixed in their height wholly by the space required to assemble the work conveniently. These buildings are often equipped with cranes at two levels, a lower one at the ordinary machine shop level, 20 to 24 ft. from the floor, and an upper crane sufficiently high to pass over the lower one, or 30 to 35 ft. from the floor. Such a building will have to be 40 to 50 ft. high.

Boiler shops, where extreme sizes of marine boilers are made, require a height of about 60 ft., and are the highest of the manufacturing buildings usually encountered.

Assuming usual conditions, a manufacturing building erected in the open, one-story high, with a width of 60 to 70 ft., having shafting attached to the roof supports and provided with overhead trolleys, should have a clear height of about 16 ft. If the machines in such a building are all motor driven and no overhead shafting or belting is required, this height had better be increased to 18 ft. Smith shops and foundries should be somewhat higher than machine shops in order that better ventilation may be secured.

The limits of this article will not permit taking up in detail the different classes of manufacturing buildings and giving an example of each under its possible conditions, therefore only a brief general outline has been attempted. The tendency is to make buildings too low. It is better to be liberal in this feature; then as the product increases in size, as it usually does, the structure can be readily adapted to the changed conditions.

James H. Edwards.

The Contractor's Transportation Problems.

The handling of materials on a large contract is a problem having a far greater effect on the cost of operations than a casual observer would believe possible. One of the famous building contractors of the country once asserted that before the advent of the Norcross-type derricks it cost him more to move a large block of stone around two sides of a building site than to ship it 500 miles by railroad. Allowing for overstatement due to marked satisfaction with such derricks, the fact remains that even in the case of such a limited area of operations as a city block, the handling of materials is a problem second only to the handling of the men. Where the works are of large extent and located at a considerable distance from the railways the problem becomes still more complicated. In work on a navigable body of water, a dilapidated steam tug or wornout freight boat is often put in service long enough to worry all the contractor's representatives by its perverse habit of breaking down; then the shipping is let to some vessel owners who have the facilities for the purpose. In other cases, where there is a long haul by team and the amount of material to be handled is large, a considerable number of poor mules and horses and incompetent teamsters will often be engaged on the supposition that any old thing is good enough for transporting building materials, provided a good superintendent is engaged to manage the work. The result is generally disastrous, and after a hopeless struggle against the combination of incompetence and poor equipment the hauling will probably be let to sub-contractors for teaming. This transportation problem has assumed serious proportions on some extensive contracts in the West, where it has been found exceedingly difficult to collect a force of competent men and good teams.

As a general proposition it may safely be asserted that there is no single feature of construction work that will repay investigation better than that of transportation. Many undertakings are situated on railroad lines and the handling of materials is accordingly a simple matter. But wherever much teaming has to be done in either cities or the country, some of the many forms of mechanical transportation deserve study. Industrial railways, traction engine trains and motor wagons offer possibilities that are little appreciated.

The Recommended Plan for the Panama Canal.

In the last issue of The Engineering Record some general comments were made on the Isthmian Canal situation as developed by the President's letter transmitting to Congress the reports of the Board of Consulting Engineers and the Canal Commission on the type of canal. There are indications that the actual character of the plan of the minority of the Board of Consulting Engineers is not fully realized, and it is therefore of importance to give that plan careful consideration. In doing this the terminal harbors and approach channels, not necessarily being affected by the character of the canal proper, will not be discussed; a well-considered endeavor seems to have been made to secure a suitably protected harbor at Colon and direct entrance channels of abundant capacity at both terminals.

The prominent features of the recommended lock plan prepared by the minority of the Board, already described in this journal, are the 85-ft. summit level, the great earth dam at Gatun, 7 miles from Colon, with its top 135 ft. above mean tide, and smaller dams at or near La Boca, the series of three successive locks in the Gatun dam, the locks at Pedro Miguel, and the series of two locks at Sosa Hill at the Pacific end of the canal. It will be observed that the 85-ft. summit level of the canal extends from Gatun to Pedro Miguel, and that the water surface of the terminal lake at the Pacific end of the canal has an elevation of 55 ft. above mean tide. The locks adopted by the minority of the Board are 900 ft. in usable length and 95 ft. in usable width. The Gatun lake floods 110 square miles of territory and forms a reservoir so great that no other control is needed for the floods of the Chagres River than their reception into it and their subsequent discharge through regulating sluices at the Gatun dam.

The canal prism between the dam at Gatun and the two dams at the Pacific terminal constitutes almost the entire canal, as that portion between Limon Bay and Gatun is really a part of the approach channel. The main contention of merit made for the recommended plan is based largely on the amount of lake navigation resulting from the creation of the terminal bodies of water, about one-seventh only of the total length of waterway having a channel less than 300 ft. wide while more than two-thirds has a width of 500 ft. or more. This lake navigation certainly has its advantages, but it also has serious disadvantages. There is a large amount of channel whose submerged borders are sources of danger to ships at speeds greater than those permissible in a narrow channel. Navigation between such submerged banks is by no means free open-water navigation, although the claim has been made that it is essentially so. There are comparatively short portions in the deepest parts of these terminal lakes where the conditions of deep open-water navigation are practically realized, but those portions are so limited that they do not exercise much influence on either the real freedom of navigation within the limits of the canal or the time of vessels passing through the latter.

The discharge of the flood waters of the Chagres River directly into the lake is also an objectionable condition. It is true that the water of the lake, when at its normal elevation of 85 ft. above mean tide, will back up the Chagres River nearly to Alhajuela. It is a matter of universal experience, however, that where the total width of channel is no greater than that which will exist between Obispo and Alhajuela, high currents will take place over the course of the submerged channel and its effect will be constantly intensified in this case with the rapid increase of marginal vegetation in that portion of the Chagres under consideration. The result will be a constantly increasing tendency to bring down silt and sand in comparatively large volumes into the canal channel below Obispo. It is to be anticipated that troublesome shoalings, perhaps to a large extent, would take place in the vicinity of Obispo in consequence of this action. Experience in maintaining similar submerged lake and river channels indicates that this feature of maintenance of a submerged channel like much of that in Gatun Lake would be costly. No allowance has been made in the estimate of cost of the recommended plan for this maintenance.

It is well to observe, in passing, that as the Chagres sediment above Gamboa would be entirely held in Gamboa Lake, in the sea-level plan, and as that from the contributary streams below Gamboa would all be held in other basins, a sea-level canal would be free from this charge of maintenance. This serious feature of the deterioriation of the submerged lake channel, acting practically as a basin for the reception for nearly the entire sedimentary discharge of the Chagres from its headwaters down to Gatun, is a vulnerable point of this plan.

The weakness of the lock feature of any great ship waterway constructed as a lock canal has been convincingly set forth in the report of the Board of Consulting Engineers, and it needs but little comment in a technical journal. It is a matter of regret that the concise and forcible treatment of the lock feature of the recommended plan, found in the report, cannot be put in the hands of every citizen interested in this great project. These objections have been met by the advocates of a lock canal only by an attempt to minimize them. Their existence cannot be denied. It is said that these dangers "by proper safeguards . . . can be made very small." In other words, this great waterway should be hampered and even controlled by main features of construction, the operation of which must necessarily be attended with the gravest hazards, on the ground that, by various combinations of safety regulations or appliances which experience shows will probably not be available when most needed, such dangers may "be made very small." If there is any one thing more imperative than any other in this great engineering work it is that the plan and actual operation of the canal should both be of such character that all sensible danger would be avoided rather than courted under a palliative plea that regulative measures and appliances may make them small.

In view of the experiences at Sault Ste. Marie, to which reference is frequently made in the report, it is incomprehensible what should have induced the recommendation of so small a lock as one having a usable length of 900 ft. and a usable width of 95 ft. The 1,000x100-ft. usable dimensions of the Board's report are small enough. The Panama ship canal is no place for paring down dimensions of the essential features of construction of that great waterway for the purpose of a small reduction in cost or for any other purpose. The United States government is amply able to build the ship canal across the Isthmus which the statute requires and no cheap makeshift should receive serious consideration. The proposed locks have practically the same capacity as the present Poe lock at the Soo, and the accommodations there have already been found so limited that a lock of fifty per cent. greater capacity or more is about to be constructed to relieve the present inconvenience of even interior navigation at that point.

It is short-sighted and far from reaching an adequate conception of what is needed at the Isthmus to say that the traffic at Sault Ste. Marie is three times that of the Suez Canal, even in a limited season. The Panama canal is a waterway between oceans and not a canal between interior lakes. Its traffic will be carried in great ships to a large extent. Moreover, it should be given such capacity as to afford the freest possible accommodation for the great war ships of the future which the United States government may need to transfer from one of its ocean coasts to the other. The restriction of the capacity of the Panama Canal by these small locks, for they are small in view of the purposes for which they are designed, would be mal-administration of this great enterprise. Ships exceeding 800 ft. in length are already on the stocks, to be put into commission as soon as they can be completed. When it is remembered that not less than ten years must elapse before this waterway is open for use, and bearing in mind the rapidity of increase of ships' dimensions during the past ten or twenty years, with no reason at the present time to anticipate a decrease in that rate of growth of dimensions, it appears very unwise to choke the capacity of the Panama canal with a series of such dwarf locks at each end.

Much has been made of the statement that the submerged lake channels are capable of relatively easy and economical enlargement, as if that would in any way increase the capacity of the canal. Nothing is more fallacious. If the channel should be made 1,000 ft. wide and 100 ft. deep from Gatun to Sosa Hill, obviously no increase of traffic would result unless the throttling locks were rebuilt of much larger dimensions. Such a rebuilding of the locks would be so formidable and costly an undertaking that the Consulting Board was unanimous in the verdict that it would not be feasible to reduce even its own plan of canal with terminal lakes to a sea-level canal; much less was it contemplated to be feasible to rebuild the locks with larger dimensions. If such a reconstruction were feasible even then it would be the height of business folly to build the Isthmian Canal with locks so small that their reconstruction in any reasonable future period would be necessary. The one thing which Congress and the public should bear in mind most clearly in this business is the fact that if the Panama Canal should be built on the recommended plan, a restricted lock waterway, with all its dangers and limitations of traffic, would be fixed there for practically all time. No one can carefully read the report of the Consulting Board without seeing clearly that this conclusion was precisely what the Board had in mind; that was at least one point of agreement between the majority and the minority of the Board.

The essential impracticability of transforming a canal built under the recommended plan to a sea-level canal was indicated in the last issue of this journal. It is only needed here to add that the Consulting Board estimated the approximate cost of reducing a lock canal practically identical with that of the recommended plan to a sea-level canal with the dimensions of the Board's plan at $208,985,000, without allowance for contingencies. If the estimated cost of the lock canal of the minority plan, $139,705,200, be added to the cost of transformation, the partial cost of securing a sea-level canal by this method will be $348,690,000. The full cost of the ultimate sea-level canal would not be less than $400,000,000, exclusive of interest charges, and it might be much more; nor can any reasonable estimate be made of the time required for the work, which would be an indefinitely long period of years. These considerations show conclusively that there is no reasonable ground whatever for the expectation that a sea-level canal can be reached through the plan endorsed by the President and Secretary of War.

A careful reading of the minority report discloses one or two serious facts regarding its estimate of cost, the first of which respects the land damages. The great terminal lakes of Gatun and Sosa cover an area of 118 square miles or 75,520 acres, of which 58 square miles within the Canal Zone are owned by the United States. For some reason it is assumed that the land owned by the United States has no value; at any rate, no charge is made against the project for this submerged territory. Apparently it is forgotten that land owned by the United States has the same market value as if it were owned by any other party. If such land were worth $1,000 per acre in the market for other parties, it would have an equal value for the United States. In other words, every acre of land submerged by these terminal lakes has value which must be charged against the project, whether the United States government is its owner or a native of the Isthmus. Furthermore, it is to be observed that this flooded teritory includes about the most valuable land in the whole Republic of Panama, except the city properties of Colon and Panama, as it is the territory served by the Panama Railroad. It includes every railroad station and town at such a station from Gatun to Obispo, including those two, on the Caribbean side, and everything between the Culebra Cut and La Boca on the Pacific side, twelve or fourteen towns in all. It also includes banana plantations and valuable grazing lands, and constitutes a strip of country which, in the near future, would be covered by a large population engaged in agricultural and other industries characteristic of a prosperous and growing community. In other words it would destroy not less than four-fifths of that territory now constituting the populated country between the two cities of Panama and Colon.

It seems strange, therefore, that the minority report should base its valuation of this valuable property upon the silver prices at which the old Panama Canal Co. secured some of its lands about thirty years ago. Indeed, it scarcely seems ingenuous to strike out all consideration, in the estimate of land damages, of 58 square miles owned by the United States and put a valuation of $7.70 per acre on the remainder.

The Engineering Record has endeavored to inform itself as thoroughly as possible regarding all features of this great canal problem. It appears that the United States government has paid possibly over $2,000 an acre for land in the vicinity of Ancon Hospital outside of the city limits of Panama, and that the new Panama Canal Co. has been compelled to pay a materially higher price than that for "practically worthless jungle" in the Rio Grande basin. Indeed, if the reported experience of the United States government in obtaining land thus far from the native owners is any indication of what it would have to pay for these valuable populated lands covered by the terminal lakes, the average price might be anywhere from $250 to $1,000 an acre, making a total of not less than $18,000,000 or $20,000,000 for the submerged land of the terminal lakes. While no exact estimate can be made of this item of cost it will certainly amount to many millions of dollars, and its omission conveys an impression of eagerness, doubtless unintended, to reduce the estimated cost of the recommended plan.

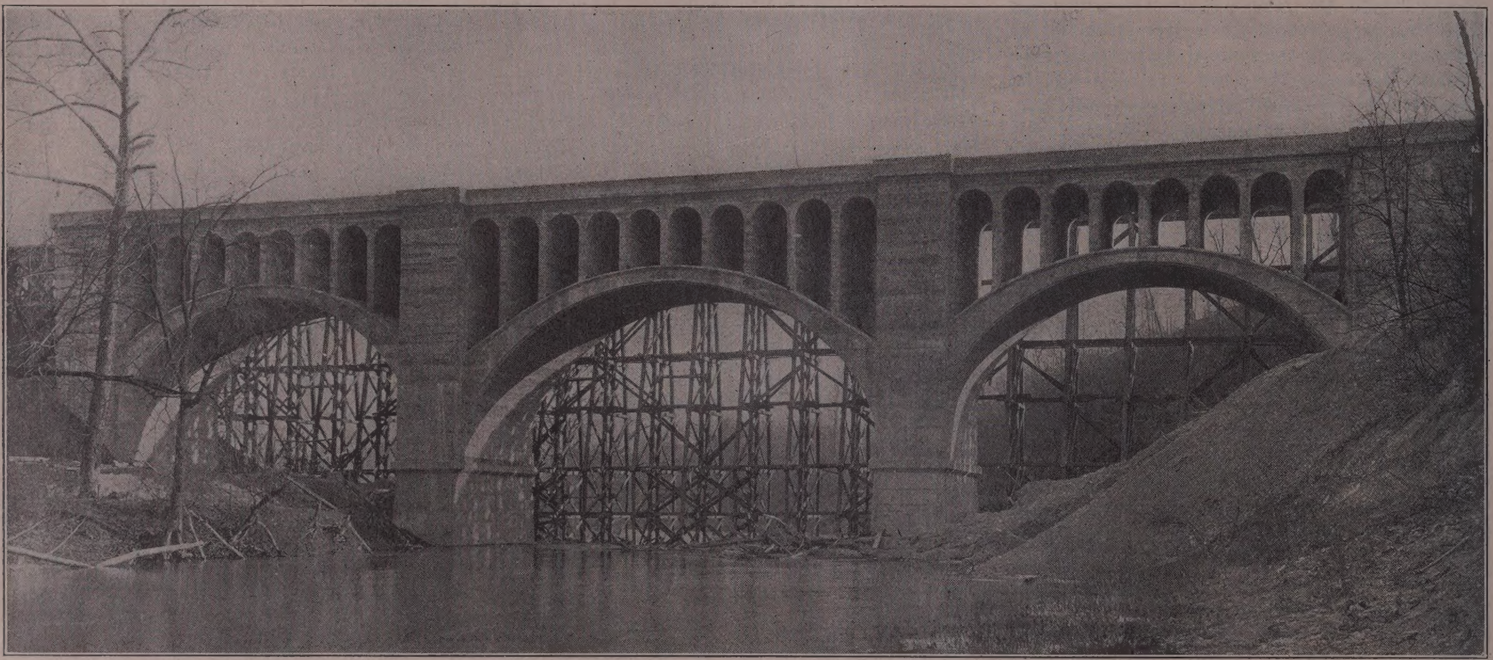
The other serious defect in the estimated cost of the recommended plan relates to maintenance and operation, and here again there is apparently a desire to obscure a material portion of the cost of operation and maintenance of the lock canal by the endeavor to insert an item equally great or greater upon the sea-level plan. While The Engineering Record does not believe that the minority of the Board had any expectation that their manner of presenting any feature of their work would have an ex-parte aspect, its report nevertheless has that character in a marked degree in the following respect. In the estimated annual cost of maintenance and operation of the sea-level canal, as made by the minority, agreeably to the method adopted by the French Co., there is found 0.7 per cent. of the total cost of excavation, amounting to $1,512,000, charged to maintenance, apparently to cover the annual cost of dredging in the prism of the sea-level canal. This was done because a similar estimate was made by the French Co. for the maintenance of the Suez Canal. Nothing could be much more unfair or unreasonable. The conditions attending the maintenance of the Suez Canal and the Panama Canal are about as dissimilar as any two conditions that can be imagined. Such an estimate would be true during some years for the light excavation of the Suez Canal, but would be little better than a wild guess for the Panama Canal. It has been shown above that while the entire sediment of practically the whole of the Chagres River would be poured into Gatun Lake in such a way as to shoal the lock canal seriously at some points, practically none of that sediment would find its way into the sea-level canal. Consequently the cost of dredging the sea-level canal would be reduced to a very small minimum.

It is difficult to find material elements on which to base the estimate of cost for this item of maintenance of the sea-level canal, for there would be little of this class of work to be done except in the approach channels at the terminals. Nor would there be any such item of maintenance as the dredging of the diversion channels, as they would maintain themselves like other streams. Looking at this matter in any reasonable way that can be imagined, it is difficult to make the cost of maintenance any more favorable for the lock plan than the sum indicated by the Board's report, which is at least $500,000 more per year than that of the sea-level plan; indeed, it would be more likely $1,000,000. Capitalizing this excess of maintenance of the lock plan at 3 per cent., as is done in the Board's report, and adding to it the land damages caused by the two terminal lakes, there should be added to the estimate of cost of the recommended plan not less than $35,000,000 and perhaps double that amount, which would bring its total cost up to $175,000,000 to $200,000,000, which is the total expenditure this government will have to face if the work should be executed on the recommended lock plan.

THE DANVILLE ARCH BRIDGE OF THE CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RAILWAY.

A Description of a Double-Track Reinforced Concrete Bridge of Unusual Design.

A double-track reinforced-concrete railroad bridge, 330-ft. long, with one 100-ft. and two 80-ft. arch spans, has recently been completed on the Cairo division of the Cleveland, Cincinnati, Chicago & St. Louis Ry., near Danville, Ill. This division of that road was originally built north from Cairo to Tilton, Ill., about 5 miles south of Danville, where it connected with the main-line tracks of the Wabash R. R. The Peoria and Eastern division of the same road is built east and west through Danville, but the Cairo division has only within the past year been extended to connect with it, owing to the exceptionally rough country which had to be crossed in the 5 miles between Tilton and Danville in building such a connection. A double-track extension of the Indiana Harbor R. R. from Osborn, Ind., to Danville was started early in 1905, and trains have recently been put in operation on it. About the same time the Indiana Harbor extension was undertaken the complete reconstruction of the Cairo division and a double-track extension of the latter from Tilton to Danville was commenced. These improvements form a direct connection with the coal fields of Indiana and Illinois for the east and west Vanderbilt trunk lines entering Chicago. The construction of the extension of the Indiana Harbor R. R. and that on the extension of the Cairo division were described in detail in The Engineering Record for Sept. 30, 1905.


View of Upstream Face of Danville Arch on the Big Four Railway.

The extension of the Cairo division joins the Peoria and Eastern division in Danville and extends west from this junction parallel to that division for a short distance over a crossing of the North Fork of the Vermilion River, the crossing being made on a fill 65 ft. high over a pair of 50-ft. concrete arches. The extension then turns to the south and about a mile further on crosses the valley of the Salt Fork of the Vermilion River. This valley is about half a mile wide and 65 to 90 ft. deep below the grade of the tracks. The north side of the valley is on a steep slope. The Salt Fork closely parallels the south side of the valley, which rises precipitously 130 ft. above the bed of the stream. The new concrete bridge structure is built with one end abutting against this precipitous bank. The remainder of the valley is crossed on a fill, 60 to 80 ft. high and wide enough on top to carry two tracks, against which the other end of the bridge is built.

The 100-ft. arch is placed in the middle, with one of the 80-ft. spans on each end of the bridge. The large arch is carried at each end by a channel pier; the stream end of each 80-ft. arch is carried by one of these piers, and the other end by one of the bridge abutments. The rise of the 100-ft. arch is 40 ft. and its springing line is 26 ft. above the bed of the stream. The rise of both 80-ft. arches is 30 ft., but their springing lines being 10 ft. above that of the larger arch, the intrados at the crown of all three arches is at the same elevation, 70 ft. above the bed of the stream. The base of rail in the tracks carried by the bridge is 19.75 ft. above the extrados of the crown of these arches. The tracks rest directly on a cushion of earth 5 ft. deep. Between the bottom of this shallow earth fill and the extrados of the arches the usual longitudinal spandrel wall on each side, with filling between, are replaced by short-span semi-circular arches built transversely to the line of the bridge on bench-walls carried up from the extrados of the main arches. These transverse arches are 2 ft. thick at the crown and their span is 8 ft. Their bench walls are 2 ft. thick and from 9 to 21 ft. high. The extrados of all of them at the crown is in the same horizontal plane, the space over their haunches being filled with concrete to this plane. A longitudinal coping, with its top at the same elevation as the base of rail in the tracks, is built over these arches on each side of the structure. The earth cushion is carried by the transverse arches and between the bridge copings.

The entire structure above the springing lines of the main arches is reinforced with Johnson corrugated bars made by the St. Louis Expanded Metal Fireproofing Co. The details of the reinforcement are shown in the accompanying illustrations. The arch ring of each of the main arches is reinforced near the extrados with longitudinal ribs made up of 33-ft. lengths of 1-in. bars, 12 in. on centers and overlapped 4 ft. at the ends. The longitudinal bars are 6 in. from the surface at the crown of the arch, from which point their depth of cover is increased to 2 ft. at the haunches. Just inside these bars are ⅞-in. transverse tie bars. The arch rings are also reinforced near the intrados with 1-in. longitudinal ribs built up and spaced the same as those near the extrados. The ends of these ribs are anchored in the masonry of the haunches. This reinforcement is arranged and the structure was built so that the three main arch rings are practically a monolith.

The series of transverse spandrel arches is built in three sections, one over each main arch ring, and the arches in each section tied together by reinforcement. The arches in each section are also separated from those in the adjacent one by an expansion joint at the top of each of the two transverse spandrel arch bench walls over piers for the main arches. The details of one of these joints is shown in one of the illustrations. The bench wall was brought up to 2 ft. below the top of the bridge floor, then 4-ft. lengths of railroad rails were placed in the concrete parallel to the longitudinal center line of the bridge. The rails were set on 4-ft. centers with the ball of the rail up and its top ⅛ in. above the surface of the concrete. The ring of the small arch on the one side of the bench wall was then built, imbedding 1.5 ft. of one end of the pieces of rail, the face of the small arch haunch over the rails being made smooth and vertical. The space between the two bench walls, in the tops of which the expansion joints are made, is covered by a flat reinforced-concrete slab, 2 ft. thick and 13 ft. wide. A bracket of concrete, 1 ft. wide, is built the length of the bench wall at the top and under this slab. A piece of rail, with the ball down and ⅛ in. below the bottom of the slab, is placed longitudinaly 1 ft. from each side of the latter. The slab bears for a width of 3 ft. on each side on the top of the bench wall; 2.5 ft. of this width is on the pieces of rail, the ball of the rails in the bottom of the slab bearing on the ball of those pieces of rail in the top of the wall. These joints are made 26 ft. long, the width of the bridge floor inside the copings at their bases. A similar transverse expansion joint is placed over the top of each abutment, 2.5 ft. below the top of the concrete.

The concrete in all these joints was made as smooth and flat as possible, and finished so that contact between the adjacent faces at the joint is made only through the rails imbedded in those faces. Two layers of felt were placed between the two surfaces of concrete and carried up to within 2 in. of the top of the vertical portion of the joints; the remaining space at the top of the vertical joints was filled with asphalt.

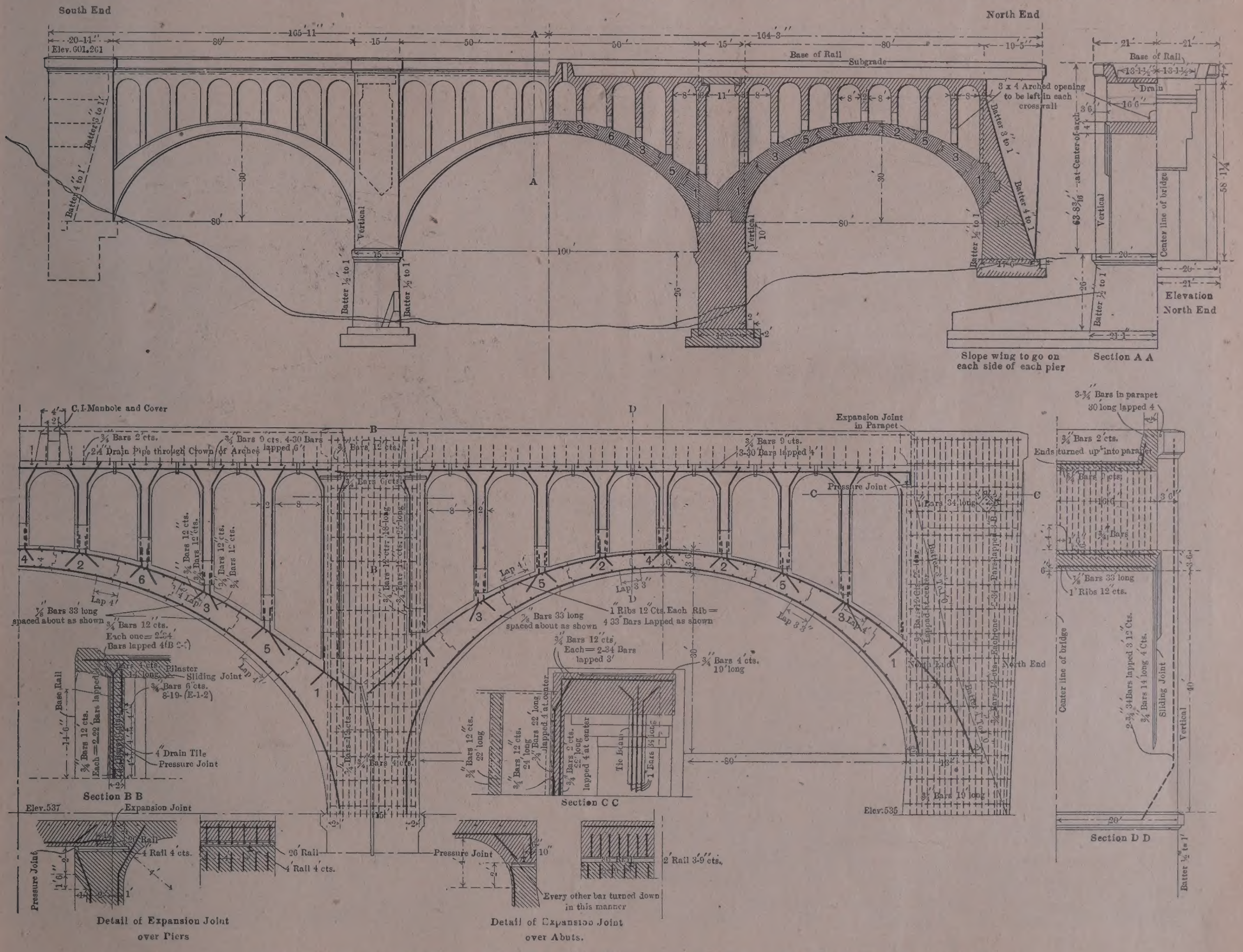
Above the arch rings of the main arches the channel piers are hollow. Each of the sides of this hollow pier is formed by one of the bench walls in whose top an expansion joint is made. Its ends are each formed by a pilaster carried up from the springing line of the 100-ft. arch. These pilasters are reinforced-concrete slabs, 3.5 ft. thick, 15 ft. wide and 57.25 ft. long, placed on end. They are reinforced 9 in. from the outer face only, by ¾-in. vertical bars placed 12 in. on centers, and by the same sized bars, 14 ft. long, placed horizontally on 4-ft. centers just back of the vertical bars. The lower ends of the vertical bars are imbedded in the tops of the channel piers. Their upper ends are extended into the 5-ft. coping on top the bridge. Each pilaster is also anchored at the top by horizontal transverse reinforcement rods in the slab over the bench walls. These rods extend into the pilasters, and are alternately bent up and down about 45 deg. at the end of anchorage. The inner face of each pilaster bears against the ends of the two bench walls over the main pier and the end of the slab over them, but is separated completely from all three by sliding joints.

The bridge is built on a shale formation, the surface of which comes about to the level of the bed of the stream. The footings for the two channel piers were carried down 10 ft. into this shale and the footing for the north abutment 4 ft. into it. The footing of the south abutment is built in the steep bank of the valley, its top being 12 ft. below the springing line of the arch of that end. The back half section of this footing was carried down 36 ft. below the natural surface to a limestone bed rock; the bottom of the front half is 6 ft. above the rock, the thrust from the arch reducing the load on that portion. The general engineering features of the bridge are too well shown in the accompanying reproductions of the plans and of progress pictures and pictures of the finished bridge to need any comment.

Construction.—The construction of the bridge was attended with unusual difficulties. The available time was quite limited, and although the work was within 2 miles of a large town, it was practically inaccessible for teams and wagons, owing to the roughness of the country and to the lack of highways leading anywhere near the work. A timber trestle, 90 ft. high, over which most of the material to make the big fill beyond the bridge had to be hauled, was erected immediately downstream from the structure, requiring the work on the latter to be carried on entirely from the upstream side. This trestle curved into the line of the tracks for the new road just beyond the north end of the bridge, and as the fill was expected to be completed up to the bridge before the latter could be finished, there was practically no space for storing concrete materials. A spur, about a mile long, was laid down from the Peoria and Eastern division, and all materials were delivered on it. This track was built on heavy grades and sharp curves, so cars could be handled with safety only when the ground was firm. It entered the valley from the downstream side of the bridge and extended under and beyond the trestle from which the big fill was made, to the upstream side for about 8 car lengths, the part above the bridge, being from 150 to 200 ft. from the stream. No storage space was available on the land side of the spur, and as the concrete mixing plant had to be located between the latter and the river, practically no space on that side could be used for storing materials.

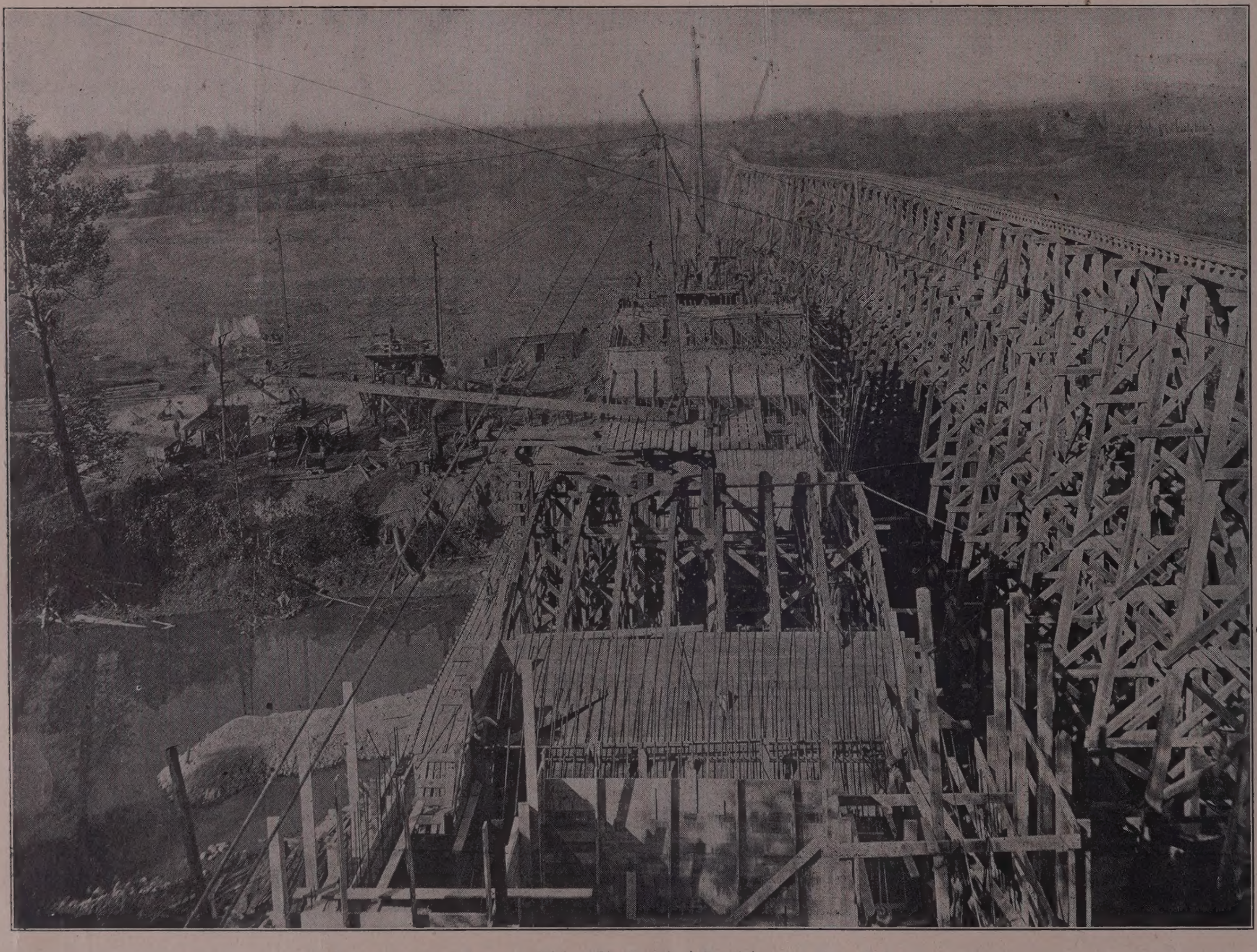
Concrete Mixing Plant.—The concrete mixing plant was arranged so it could handle materials from cars on the track, or from small storage piles along the river side of the latter. It was built about 50 ft. upstream from the upstream side of the north channel pier, 100 ft. from the bank of the stream and 50 ft. from the track. A storage house for cement, with a capacity of 10 cars, was erected on the other side of the track from the mixing plant. A guyed derrick was set between the track and the mixing plant, and the concrete materials were handled in a clam-shell bucket by this derrick between the cars, or between the storage piles and the plant.

A ¾-yd. Smith mixer was used in making the 12,000 cu. yd. of concrete required to complete the bridge, and was run without repairs throughout the work. It was set on a timber platform about 7 ft. above the ground. A measuring hop-



Reinforced Concrete Bridge on the Big Four Railway over the Vermilion River near Danville, Ill.

per was placed over the mixer and connected with a double storage hopper, the top of which was about 15 ft. above the mixer platform. Each compartment of the double hopper held 8 cu. yd., one being for stone and one for gravel. The clam-shell bucket discharged into these compartments. A service track was laid from the cement storage house up an incline to the level of the measuring hopper. The cement was hauled up this track on small flat cars by a rope attached to one of the spools on the hoisting engine for the derrick. The hoisting engine had only 2 drums and 2 spools and as the clam-shell bucket required three lines, an extra line with a counterweight was attached to one of the spools and arranged so it could hold the slack in the loading line. The mixer discharged into ¾-yd. buckets on push cars on a service track laid under the mixer platform.



Arrangement of Concrete Mixing Plant and of Derricks over Main Arches.

The platform was operated by 7 men; one man on a platform around the measuring box over the mixer to measure and dump the materials into the latter, one man on the same platform to clean up, one man on a platform level with the top of the stone and gravel hoppers, two men handling cement on push cars from the cement storage house to the plant, and a fireman and an engineer for an engine which operated the mixer and the derrick connected with it. The plant was capable of handling 200 cu. yd. in 10 hours under normal conditions, the greatest limitation to speed in its continuous operation being the lack of storage space for materials.

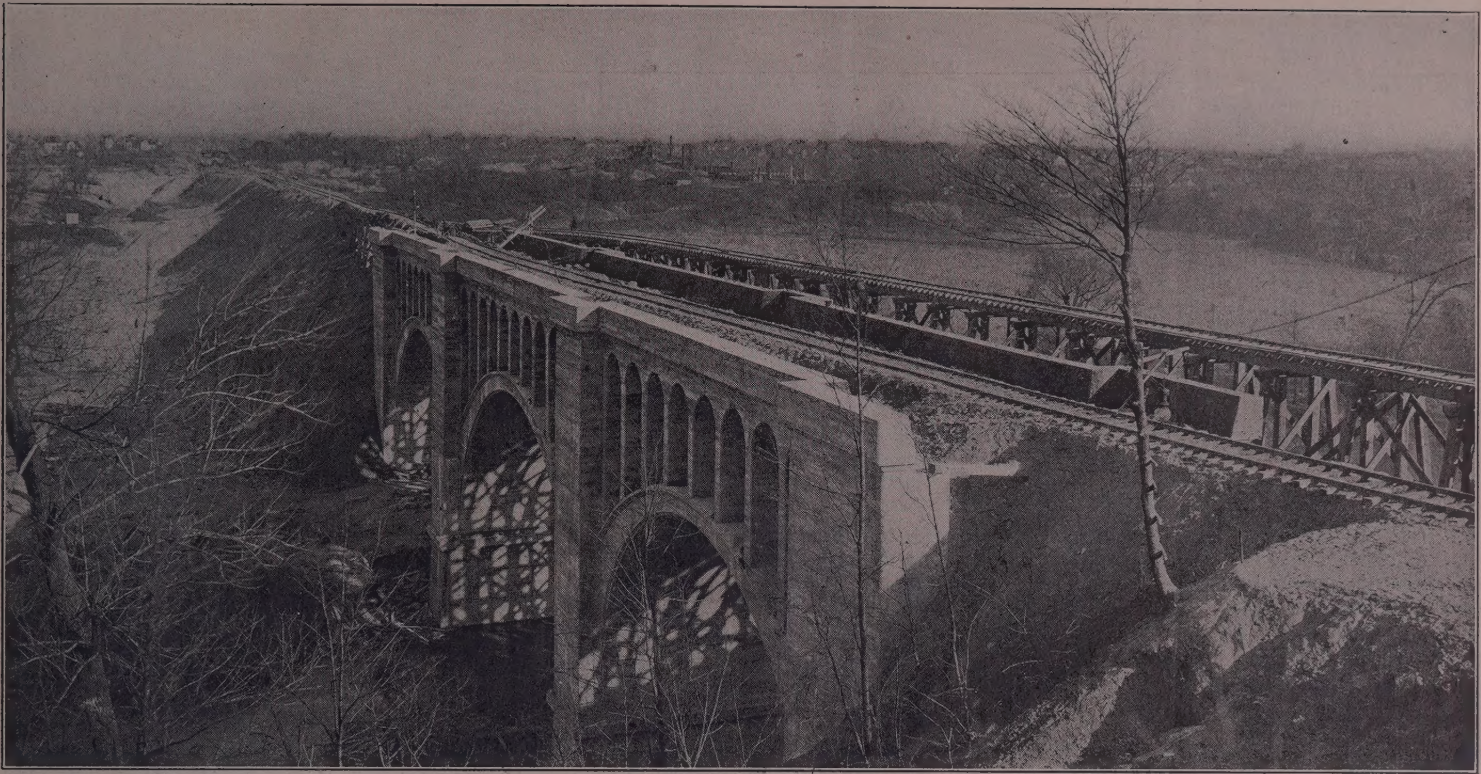
Construction of Footings and Piers.—The excavations for the footings for the piers and abutments were made without much difficulty. Four guyed derricks, with 70-ft. booms, one derrick for each abutment and one for each pier, were set up on the ground so they could serve the work on this part of the structure. The excavations for the north pier and for the north abutment were heavily sheeted and the sheeting well cross-braced to avoid caving. The shale into which the excavations were carried had to be loosened with light blasts before it could be removed. The loosened material was taken out in ¾-yd. buckets by the derricks and wasted within range of the derrick booms.

The service track laid under the mixing plant, and on which the cars carrying buckets into which the mixer dumped were operated, extended at right-angles to the line of and to within 20 ft. of the upstream side of the bridge. It was connected there through a turntable to a double service track laid parallel to the latter. This double track was built across the stream on a trestle and extended far enough in both directions from the center of the bridge so the derricks used in the construction, when located near the bridge, could easily reach cars on it.

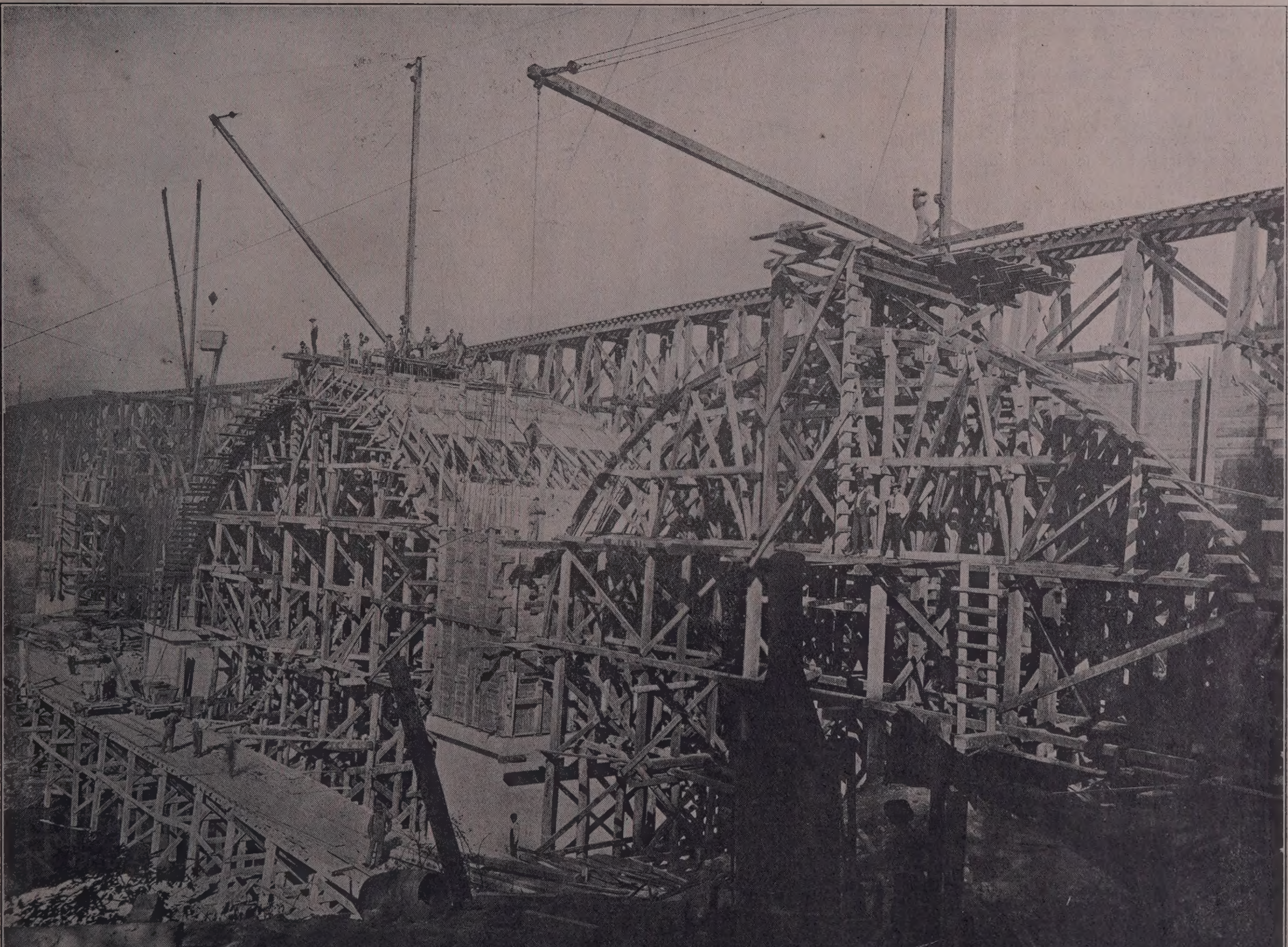
Falsework and Centering for Main Arches.—The concrete in the piers and abutments was carried up to springing lines of all three main arches as soon as the footings were finished. The falsework and centering for the 100-ft. arch was erected as the work on the lower portion of the piers and abutments approached completion. The falsework for each of the three arches consisted of six transverse bents with eight 8x10-in. plumb posts to a bent. The bents were carried up in 22-ft. stories, with 8x10-in. caps at each story. They were thoroughly sway-braced every 11 ft. of height above the tops of the main piers by horizontal 4x8-in. timbers to each longitudinal row of posts, and were also X-braced transversely in 11-ft. stories by 3x10-in. plank. Each plumb post was placed on a pile driven 4-ft. into the shale and sawed off accurately to take caps on which the posts were set.

Eight longitudinal timber ribs were provided to carry directly the lagging for each arch ring. Each of the ribs was placed over one of the longitudinal rows of timbers in the transverse falsework bents, and supported at 14 points by centering built up on caps on the top of the falsework. The ends of each rib were attached to caps over the end posts in each longitudinal row of posts. A 6x8-in. plumb-post and three 4x8-in. inclined struts were placed over each of the intermediate posts in the longitudinal row. A 6x8-in. plumb-post, with two 4x8-in. inclined struts on each side of it, was placed over each of the two central posts in those rows. These plumb posts and struts of the centering were bolted at the top of the ribs, but were only braced against each other at the bottom and not attached to the falsework. The arch ribs were made of four 2x12-in. plank, shaped and bolted together on the ground, in 20 to 25-ft. sections and hoisted into place by the derricks. The lagging for the arch rings consisted of 3x8-in. planks dressed on all sides.

Construction of Main Arches.—The concrete in the main arches, in the piers and abutments above the springing lines of those arches and in most



View of South End of Danville Bridge on Upstream Side.



Falsework for Main Arches of the Danville Bridge Showing Location of Derricks.

of the transverse spandrel arches was handled from the double service track on the trestle over the stream to position in ¾-yd. buckets by 3 guyed derricks, one over the crown of the centering for each main arch. Each derrick was carried on a platform about 4 ft. above the extrados of the arch over which it was placed. These platforms were erected on a falsework carried up from the ground and were entirely separate from the falsework and centering for the arches. This platform falsework consisted in each case of a 4x10-in. plumb post at each corner, set on a pile cut off at the springing line of the 100-ft. arch. One of the derricks was operated by an American Hoist & Derrick Co. engine and the other two by Lidgerwood hoisting engines set on the ground.

The arch ring of the 100-ft. span was divided into 11 and the arch ring of each 80-ft. span into 9 transverse sections, as shown by the numbers on one of the accompanying illustrations. The blocks over the tops of the two piers up to the springing lines of the 80-ft. spans were laid first after the falsework and centering had all been erected. The concrete in the 100-ft. arch ring was laid as soon as these blocks were in place. The transverse sections of the arch ring numbered 1 were laid first, those numbered 2, second, 3, third and so on, as indicated. The transverse sections in each pair were laid in one shift, the concrete being dumped successively on one side and then the other in order to keep the thrusts equalized. The south 80-ft. arch was built after the 100-ft. arch was finished and when it was completed the concrete for the north 80-ft. arch was laid. The successive method of building the transverse sections in the 80-ft. arches was similar to that followed in the 100-ft. one, varying from the latter as indicated by the numbers on the sections in the illustrations. The longitudinal reinforcement bars in the arch rings were always lapped as near the middle of a section as possible.

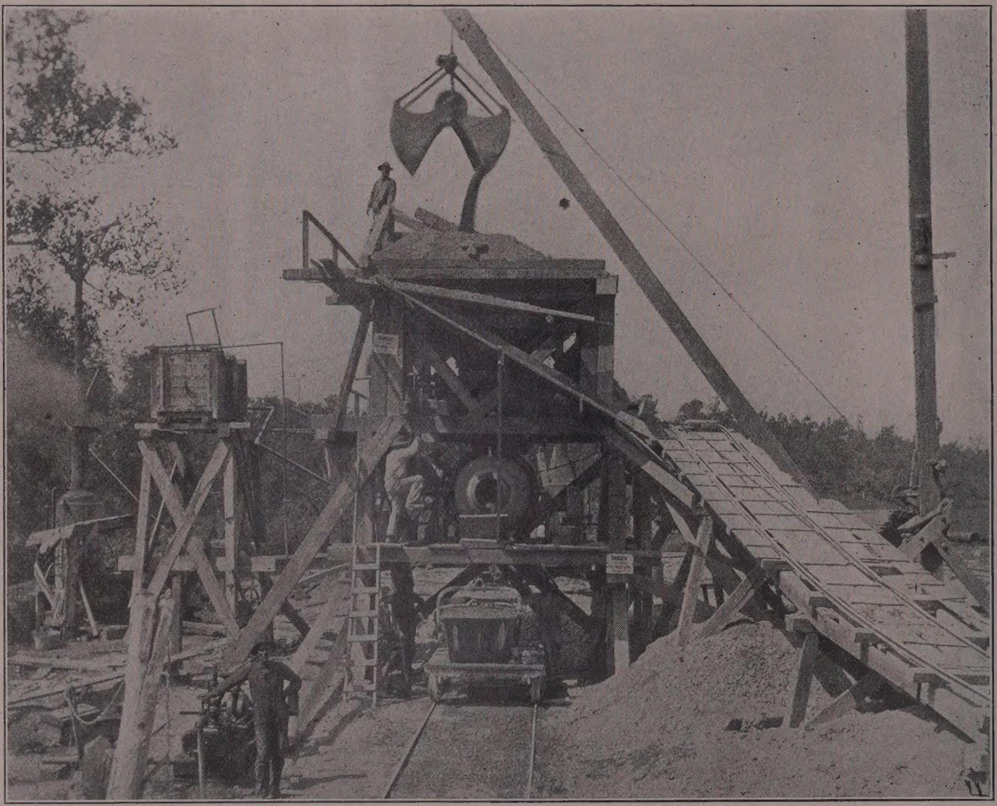
The bench walls for the two spandrel arches on each side of the south pier were built up after the 100-ft. and the south 80-ft. arches had been erected. The pilaster over the ends of the south pier were brought up about the same time these four bench walls were built. The slab covering the space enclosed by the pilasters and the two bench walls over that pier was laid soon after these pilasters and bench walls had been completed. The bench walls for the two extreme south spandrel arches and the south abutment were then carried up to the springing line of the small arches. Following that the centering for the south 80-ft. arch was lowered, and subsequent to that two spandrel arches each side of the north pier were completed before the remaining five spandrel arches over the south 80-ft. arch were covered. This latter work was followed by carrying the north abutment up to the coping and building the two spandrel arches next to it. The spandrel arches over the 100-ft. arch were completed next and those over the north 80-ft. arch last. Each of transverse sections of the main arch rings carries one bench wall for the spandrel arches. These bench walls are 2 ft. thick and 10 to 21 ft. high. They are reinforced near each face by vertical ¾-in. bars placed 12 in. on centers. These bars overlap at the base of the wall with bars of the same size which extend into the main arch ring and are bent in such manner as to be anchored. Those in each wall also extend at the top over the haunches of the adjacent arches. A level step was made at the bottom of each wall by carrying the concrete up 4 in. to 1 ft. on the low side where the main arch ring is curved when the sections of the latter were built. The reinforcement bars in the bottom of those walls were also placed in the concrete of the arch rings as it was laid. The forms for these walls being so high and narrow and the reinforcing bars reducing the limited space between the forms, the concrete in them was laid with considerable difficulty. Long-handled wooden paddles were used effectively, however, and the finished concrete as it came from the forms has a very good appearance.

The derricks for the 100-ft. and the south 80-ft. arch were both removed before the central spandrel arches over those arches had been built. Holes had been left in each of the main arch rings around the plumb posts which carried the platforms of the derricks. When the platforms and the posts carrying them had been taken down, a form was built over the bottom of these holes and the latter filled with concrete. The derrick that had been over the south 80-ft. arch was raised up and set on the finished concrete. Then a service track was laid longitudinally over the work that had been done and the buckets of concrete were elevated by the derrick and handled to place on push cars on this track. The north derrick was also moved in the same manner before the spandrel arches over that main arch were closed, and handled the concrete for the final work on that end of the bridge and for the coping.

Trestles carrying service tracks level with the top of the coping were erected longitudinally on each side of the bridge on the finished concrete of the spandrel arches. The buckets of concrete were elevated from the double service track at the foot of the bridge to push cars on the tracks along the copings and delivered in place. The copings were carried forward on both sides together, in alternate 20-ft. sections, and were completed in 4 days.

Forms.—The lagging for the forms for the piers, pilasters, abutments and the bench walls of the spandrel arches were 2x8 and 2x10-in. dressed plank, with varying sizes of timbers for posts, depending on the height of the form. The forms for the main arches were described under falsework and centering for those arches. The lagging for the spandrel arches was 1x3-in. matched flooring. All the pairs of vertical forms were tied together with wires and well braced in position.

Removing Centers.—The falsework and centering for the main arches was removed in the same manner in all three cases. Wedges placed between the timbers carrying the centering for the arches and the caps on the falsework bents were first struck. Then the braces were removed from the falsework and the bents of the latter pulled out by a line on a hoisting engine. The two bents at each end were taken out first and then the two central ones. The falsework of each arch was removed in an hour in this manner. After it had been taken out, no perceptible settling of the arches could be detected.



Concrete Mixing Plant Danville Arch Bridge.

Concrete.—Three classes of concrete were used: one in the footings, a second in the main arch rings and a third in the abutments and the remainder of the bridge. The specifications required the first class to be mixed in the proportions of 1 part Portland cement to 9½ parts gravel, or 1 part cement, 4 parts sand and 8 parts broken stone; the second, that in the arch rings, was required to be 1 part cement to 2 parts sand and 4 parts broken stone; and the third, 1 part of Portland cement to 6½ parts gravel, or a 1:3:6 mixture of cement, sand and broken stone. The gravel obtainable for the gravel concrete was too fine to be used in the proportions specified. For that reason enough broken stone was added to produce concrete of about the same quality as that required for the two classes. The broken stone used would pass a screen with a 2-in. mesh. The gravel graded from coarse sand to stone 2 in. in their greatest dimension. Red Ring Portland cement, made by the St. Louis Portland Cement Co., was used exclusively, over 12,000 bbl. being required. The concrete was made quite wet and in all cases was spaded well back from the forms on exposed faces, but was neither faced with mortar in the forms nor plastered after the latter were removed. The appearance of the resulting concrete is good, as may be seen from the accompanying illustration of the finished bridge.

Time.—Concrete work was commenced Aug. 8, last, but owing to delays in securing materials, work was not commenced on the main arches until Oct. 4. The structure was completed Dec. 17. One 10-hr. shift was worked all of the time, and the structure could have been completed in a shorter time, if delays had not been occasioned in the procuring of concrete materials. The magnitude of the structure is emphasized by some of the quantities connected with its construction. The centering, falsework and forms required 500,000 ft., board measure, of lumber; the total exposed surface is 92,000 sq. ft., 260,000 lb. of Johnson corrugated bars were used and 700 cars of materials were necessitated in the construction, all of the latter being handled on the spur track, with storage room for only 8 cars.

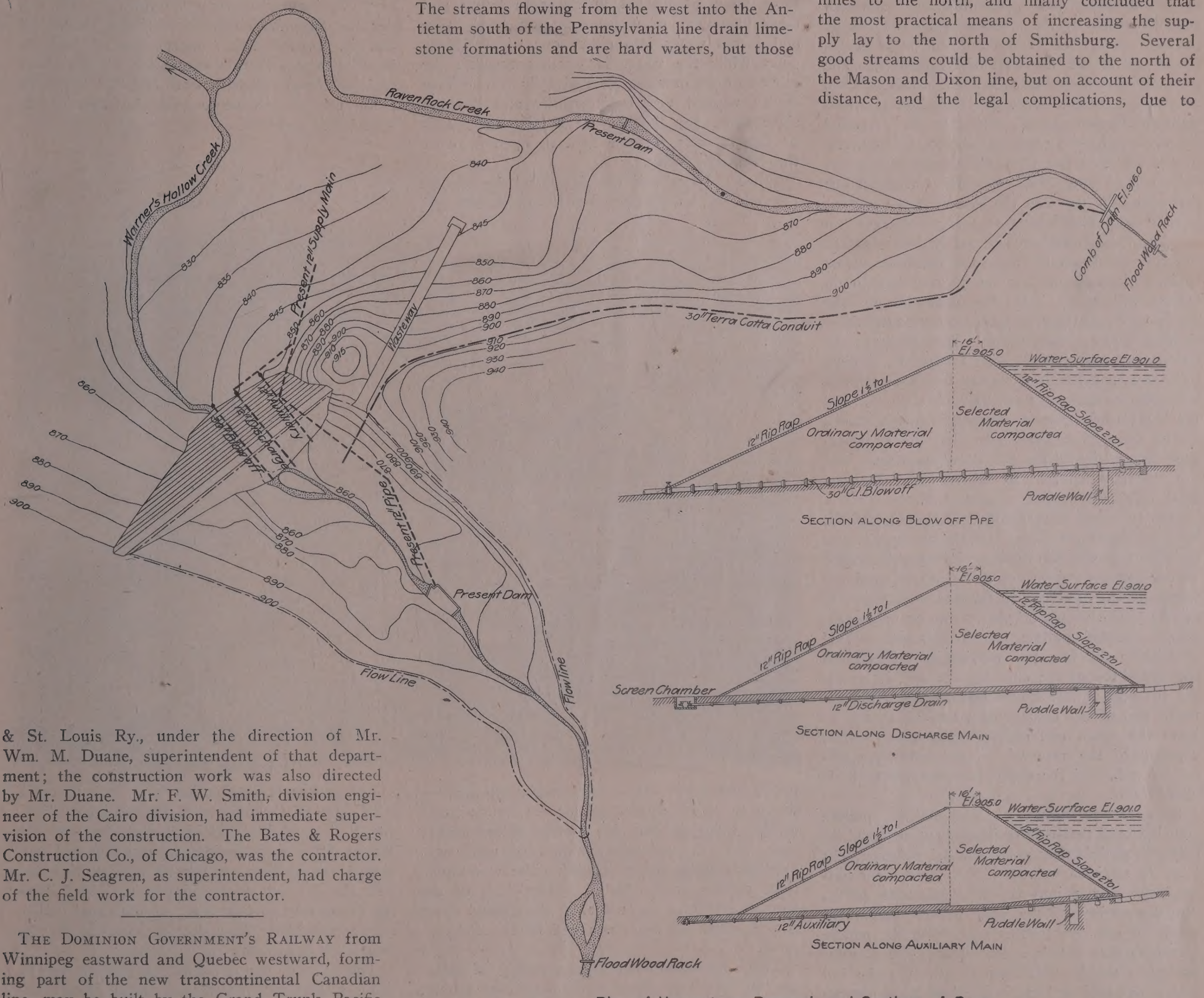
The bridge was designed in the construction department of the Cleveland, Cincinnati, Chicago & St. Louis Ry., under the direction of Mr. Wm. M. Duane, superintendent of that department; the construction work was also directed by Mr. Duane. Mr. F. W. Smith, division engineer of the Cairo division, had immediate supervision of the construction. The Bates & Rogers Construction Co., of Chicago, was the contractor. Mr. C. J. Seagren, as superintendent, had charge of the field work for the contractor.

THE DOMINION GOVERNMENT'S RAILWAY from Winnipeg eastward and Quebec westward, forming part of the new transcontinental Canadian line, may be built by the Grand Trunk Pacific Ry. Co. as contractor. This has been reported for some time as possible and Mr. Wm. Wainwright, a director of the road, has confirmed the rumor. Under the agreement of 1903 between the company and the Dominion government, the former pays the latter for 43 of the 50 years of the lease a rental equivalent to 3 per cent. of the cost of construction. It is obvious that the company is desirous of having the road built as economically as is consistent with a good roadbed. The portions of the line for which it is considering the advisability of submitting bids are nearly four hundred miles long, and an economy of only ten per cent. in building this line amounts to a large total sum.

The Hagerstown Reservoir.

By J. W. Ledoux, M. Am. Soc. C.E.

The water-works of Hagerstown, Md., is owned by the Washington County Water Co., which takes its supply from the Blue Mountains in the vicinity of Smithsburg and Edgemont, near the Western Maryland R. R. In this vicinity the mountain forms the eastern side of the Antietam valley, which is a very fertile and prosperous farming country. The river rises some fifteen miles to the north of Smithsburg, flows southwardly and passes about three miles to the east of Hagerstown. The entire valley is composed of a limestone formation, and in the vicinity of Smithsburg contains numerous caves. The streams flowing from the west into the Antietam south of the Pennsylvania line drain limestone formations and are hard waters, but those flowing down from the mountain side on the east are soft in quality, the formations being shale and sandstone.



SECTION ALONG BLOW OFF PIPE

SECTION ALONG DISCHARGE MAIN

SECTION ALONG AUXILIARY MAIN

Plan of Hagerstown Reservoir and Sections of Dam.

The Washington County Water Co.'s supply is taken from the streams known as Raven Rock and Warner's Hollow Runs, which cross the Western Maryland R. R. about one and one-half miles south of Edgemont. The company had also appropriated to a small extent the water of Diffendall's Run, which flows through the south edge of Smithsburg, and had in use a 20,000,000-gal. distributing reservoir situated between Smithsburg and Cabetown. From Raven Rocks Run to Hagerstown, by way of the distributing reservoir, there was in use a 12-in. cast-iron supply pipe; but up to 1902 no further storage reservoirs had been built. The Diffendall's Run contains approximately four square miles of watershed, and the combined drainage area of Raven Rocks and Warner's Hollow Runs at the Western Maryland R. R. was about six square miles. As all these mountain streams were subject to extremes of flow, say from 40,000 to 100,000,000 gal. per square mile per 24 hours, and the requirements at Hagerstown were about 1,000,000 gal. per 24 hours in the dry season, the supplies had been for several years inadequate. When the writer made the examination, he visited all the streams for a distance of about ten miles to the south of Smithsburg and about fifteen miles to the north, and finally concluded that the most practical means of increasing the supply lay to the north of Smithsburg. Several good streams could be obtained to the north of the Mason and Dixon line, but on account of their distance, and the legal complications, due to taking water outside of the State of Maryland, their appropriation was considered not advisable. After a thorough study of the problem, it was deemed best to build storage reservoirs on the streams already occupied, and for this purpose a study of the rainfall, evaporation and run-off conditions was made. The annual rainfall at Hagerstown is shown in the following table:

1886..36.87	inches	1892..34.34	inches	1898..32.13	inches
1887..32.97	"	1893..32.04	"	1899..38.09	"
1888..41.68	"	1894..35.62	"	1900..37.21	"
1889..52.77	"	1895..36.67	"	1901..44.02	"
1890..46.2	"	1896..33.03	"	1902..45.71	"
1891..45.9	"	1897..38.68	"	1903..48.25	"

The amount of water available with the limited amount of storage in use up to the latter part of 1901 was approximately 750,000 gal. per 24 hours, and to provide for their needs at that time the water company was purchasing water from a spring in Hagerstown at a cost of 9 cents per 1,000 gal., and were obliged to pay for the cost of pumping in addition. Besides that, a chemical analysis showed that the quality of water in the spring was badly suited for manufacturing, and hardly safe for domestic use.

Surveys and borings were made to determine the size and best location for one or more storage reservoirs. It was found that there was no first-class site for a dam on any of the streams known as Diffendall's, Warner's Hollow or Raven Rocks Runs, and an investigation was made to determine whether a storage reservoir could be built in the neighborhood of Smithsburg, to which reservoir each of the streams would be led by gravity. An excellent site for this purpose was found just to the northeast of Smithsburg. The topography and convenience adapted this location admirably to the purpose, but investigations showed the formations underlying the proposed reservoir to be of cavernous limestone, and therefore it was considered too risky to build a reservoir on this site. This conclusion was further verified by the fact that the bottom of the present 20,00,000-gal. distributing reservoir had caved in several times previously, forming crevices that could be explored by rod to a depth of 40 or 50 ft. There seemed to be nothing left to do but to utilize the best site obtainable on the sandstone formations of one or more of the three streams under consideration. The natural conditions and topograph indicated Warner's Hollow to be the most feasible, but like the other valleys, the rock formations were badly broken up, and the ledges almost approximated in appearance a pile of loose rock fill, except that the stratifications were discernible but never regular. The dip averaged from 0° to 80°, and the direction of the strike averaged at least 100°.

The reservoir was finally designed and built by The American Pipe Manufacturing Co. approximately as shown in plans. The puddle trench varied between widths of 5 and 10 ft., and between depths of 6 and 20 ft., and in addition to puddle trench shown on plan, as an extra precaution, a second puddle trench was run nearly parallel to the first but starting upstream from the upper toe of the embankment and intersecting the first puddle trench about 50 ft. from the north end of the embankment and about 200 ft. from the south end of the embankment. The capacity of the reservoir is approximately 96,000,000 gal., and the depth of water, as built, is about 52 ft.

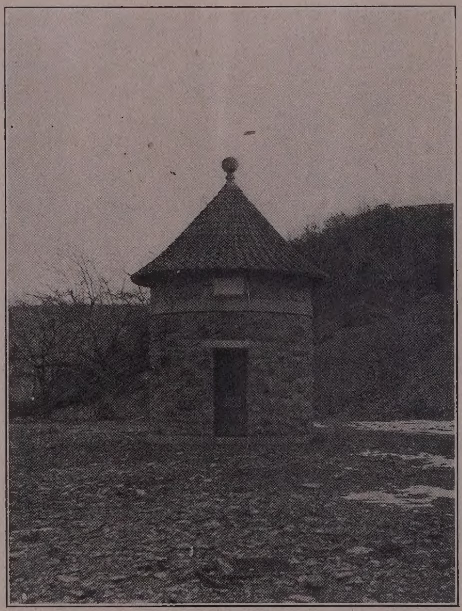
In order to determine whether the puddle trench would reach more impervious material by being carried farther north toward Raven Rocks Run, in addition to test pits, a drift or cross-cut, was driven into the hillside about 40 ft., but the quality of the rock proved that there would be no advantage in continuing the puddle trench farther than we did. Under the circumstances a considerable seepage through the hill was anticipated at least in the beginning, but no apprehension was entertained for the safety of the dam, and it was decided that if the seepage were not reduced to a nominally small amount this water could afterwards be collected in a small storage reservoir below the dam, and at intervals be utilized for the regular supply, the head being sufficient for this purpose.

It was barely possible to find a sufficient amount of suitable material to fill the puddle trench, and the impervious portion of the embankment, and therefore the downstream half of the embankment was made of earth and loose rock. The intake dam on Raven Rocks Run was built of masonry. A 30-in. vitrified pipe with corrugated joints and deep bells was used to convey the water from Raven Rocks to Warner's Hollow reservoir.

The construction of the spillway is rather unique and is shown clearly in the plan.

An unusual but minor feature not shown on the plan consists in the method of opening the 30-in. blow-off valve. This 30-in. pipe was provided with a gate located in the gate house and an additional gate above the upstream toe of the embankment. The latter is provided with a hydraulic cylinder having two ¾-in. pipes, one connected with the top and one with the bottom of the cylinder. These pipes then lead to a four-way valve located in the gate house, and they are supported in the top of the 30-in. blow-off pipe by means of small hanger bolts. A hand force pump is located in the gate house and takes its supply of water from the supply pipe and forces water into either one of the ¾-in. pipes while the water is wasting through the other to open or close the hydraulic valve. This device worked very satisfactorily and has not since given any trouble. It requires only four or five minutes for one man to open or close the hydraulic valve.

When the reservoir was first filled the seepage through the hill amounted to about 800,000 gal. per 24 hours, but after a few months this was reduced to about 300,000 gal. per 24 hours. Some of this reduction was due to natural sedimentation, but a considerable amount of work was expended in an effort to silt up the worst portions of the north sidehill. Nearly all of the seepage comes to the surface of the ground about 300 ft. north of the north end of the embankment.



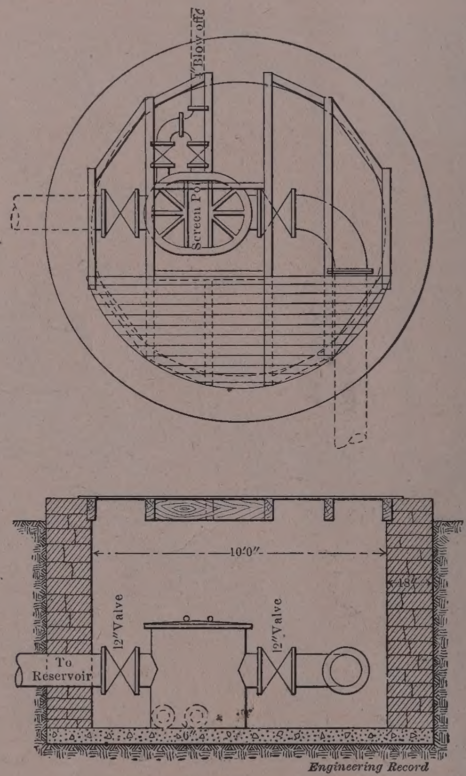
Gate House.

There has been an adequate supply of water for the city ever since the reservoir was built, and therefore no attempt has been made to collect and utilize the water seeping through the hill. The conditions are such that it is hardly likely that this seepage will entirely cease, but it will not average more than 150,000 gal. per day for the period when the reservoir is drawn below the spillway. When full, the loss is about 300,000 gal. per 24 hours; when the reservoir is drawn down 4 ft., 190,000 gal. per 24 hours; 7 ft., 145,000 gal.; 10 ft., 120,000 gal. per 24 hours, and finally reaches zero when the reservoir is drawn down to about 25 ft. below the spillway.

The total amount of water obtainable from this reservoir alone, after deducting 150,000 gal. per 24 hours for leakage, is calculated to be not less than 1,135,000 gal. per 24 hours, which represents a net increase of water supply, due to this storage reservoir, of about 900,000 gal. per 24 hours. Work on the reservoir was begun in the spring of 1902 and finished in the summer of 1903.

A Legal Criticism of Government Specfications.

In a recent visit to some of the Middle Western States, on legal business connected with government contracts, Major William E. Harvey, of the firm of George A. & William B. King, members of the bar of the Court of Claims at Washington, had occasion to meet a number of contractors engaged in railroad work, who have considered the question of bidding upon government work, particularly upon the contracts under the Reclamation Service of the Geological Survey. He found that among many of the leading contractors there was great hesitation about undertaking government work and that this hesitation very largely arose from the form of the specifications.



Gate House Arrangement.

The matter was taken up later in conference with some of the officers of the Geological Survey, and at their suggestions the views of the Messrs. King were embodied in writing and submitted for further consideration in connection with the drafting of specifications. The following is the text of the paper so submitted, which quotes particularly from the specifications for the Fort Buford project:

The basis of the following suggestions is (1) conversations with contractors in the West; (2) study of the decisions of the Supreme Court and the Court of Claims and experience in cases in those courts.

Definition of "Engineer."—This specification defines the "engineer" wherever it occurs in the specifications, as "the chief engineer of the Reclamation Service, or any of his authorized assistants or inspectors, limited to the particular duties entrusted to them." Throughout the contract many duties are imposed upon the engineer, leaving to inference from this definition who is the particular engineer intended in connection with each duty.

This is objected to by contractors because, when any subordinate inspector or engineer gives them orders, the contractor must ascertain at his own peril whether the particular officer is within the limits of his own particular duties. The contractor should know definitely who can authoritatively give him orders in each detail of his work.

Risk of Conditions.—"Local Conditions.—Bidders must satisfy themselves as to the nature of the material and as to all local conditions affecting the work, and no information derived from the maps, plans, specifications, profiles or drawings, or from the engineer or his assistants, will in any way relieve the contractor from any risks or from fulfilling all the terms of his contract."

In the specifications, the government makes representations of the work required and furnishes plans and maps indicating the route of the work and the conformation of the ground. This information is supposed to be based on preliminary surveys and an engineer is designated in the advertisement to furnish contractors "particulars." After information is thus given them, they are told that they cannot rely upon it.

View of Spillway and Dam, Hagerstown Reservoir.

Prospective contractors, preparing to bid cannot undertake these preliminary studies anew; they must actually base their bids on the conditions which are shown by the preliminary surveys of the government.

They may: (1) Bid on the government surveys, and, if prudent, add to their bid an indefinite sum to meet the contingency of their being incorrect, or (2) gamble on the chance of all the official information being incorrect, by bidding at such a figure as to lose if not correct.

We are aware that preliminary studies, even when most carefully made, are subject to error by undisclosed conditions, but, when carefully made, they generally disclose the real conditions.

Which party should bear the burden of undiscovered conditions? This question may be answered:

(1) As the United States is responsible for the investigations, the responsibility for their correctness should normally fall on the government, rather than on the contractor.

(2) Certainty should always be a feature of contracts. If the preliminary studies are taken as the basis of the contract the gambling risk is eliminated; both parties know what the contract proposes to do. If unexpected conditions are found, either cheapening or increasing the cost, provision can be made for a change of price, so that whatever the work, it may be fairly paid for.

(3) It does not conduce to a good job that the contract is executed at a loss. It is thus not to the interest of the United States to force a contractor who meets unexpected conditions to complete the work at a loss.

(4) The United States cannot desire to ruin a contractor who finds unusually expensive, undisclosed conditions.

For these reasons the preliminary surveys should be taken as the basis of conditions to be met and the contract should provide a mode of adjustment if these turn out erroneous.

Since the specifications attempt to throw on the contractors all of the responsibility for the preliminary work of the government, it is not surprising that many contractors whose reputation assures them of remunerative work for parties on fair terms, object to bidding on them.

The Government's Delays.—Delays: The contractor shall not be entitled to any compensation for delays or hindrances to the work from any cause whatever.

It is very difficult for any one to see how this provision can be justified.

(1) It introduces an element of uncertainty into all biddings. The contractor who has to assume all liability for his own delay, a matter principally under his own control, here is obliged to assume sole responsibility for all delay of government officers over which he has no control whatever. He has to make a sheer hazard on this. Such a provision tends to reduce contracting from a legitimate business to a kind of gambling.

(2) Each party to a contract should in fairness assume responsibility for his own acts. The contractor pays damages for his delay and may have his contract annulled for it; it is only fair that the other party should assume a corresponding liability to the contractor.

(3) Can the government hope to gain by such essentially one-sided provisions? Contractors of sound business judgment, if they bid at all on such contracts, must add an insurance for such risks. Contractors who do not guard themselves by so doing are not the prudent and responsible business men whom the government wants. The result is that the government is likely to get high bids or poor contractors.

To illustrate the injustice of this provision, see the many cases found by the Court of Claims of delays which contractors have suffered at the hands of the government. See also the recent decision of the Court of Claims finding two years' delay by the government on the work on the battleship "Indiana" done by the Cramp Company (Eng. Record, Feb. 17).

Changes.—Changes and Extra Work: The Secretary of the Interior reserves the right to make such changes in the specifications of work or material at any time as may be deemed advisable, without notice to the sureties or surety on the bond given to secure compliance with the contract, by adding thereto or deducting therefrom, at the unit price of the contract, or at such allowances for changes of materials as shall be deemed just and reasonable by the engineer, whose decision shall be binding on both parties.

This is wholly one-sided. The Secretary has the absolute right under this practically to cancel the contract or double it at the unit prices of the contract, or at such allowances for changes of material as may be deemed just and reasonable by the engineer. This leaves the matter wide open for one side to determine how much the contractor has to do and how much he is to earn. That this is not intended to cover trivial variations from the original plan is shown by the following sentence in the same specification that "the right to make material changes in the quantities listed in the proposal is an essential part of the contract, and bidders must make their estimates accordingly."

There should be no material variation from the quantity of the work to be done. Particularly there should be no diminution of it, because in constructing work in a remote part of the country a very large outlay must necessarily be made by the contractor in getting his plant assembled on the ground and, while the profits that he had figured on on the entire job would be sufficient to give him a profit after deducting these first costs, if the work is materially diminished, he may be deprived of all profits.

"Minor changes" are often permitted under contracts but this contract throws down all such limitations and places the contractor absolutely in the control of the engineer.

Control over Methods.—"Formation of Embankments: The earth in all embankments shall be deposited with scrapers unless special permission is given by the engineer to use another method."

The above is quoted from the specifications on the Fort Buford project. This provision, giving the engineer the right to give permission to use some other method, is subject to grave abuse.

On the Huntley project it is provided: "The earth in all embankments shall be deposited with scrapers unless otherwise directed by the engineer." This is even worse than above because the engineer has power to direct some other method. He can, if he wants, direct that the work be done by hand shovels or by machinery of a particular type.

It would be much better to specify definitely in both of these what method of work is to be permitted. If, in the judgment of the engineer, a special part of the work can be done by machinery, it should be specifically shown that the work is to be done by machinery. If a certain part of the work is to be done by scrapers, it should be so specified. If a certain part of the work is to be done by hand shovels it should be so specified.

Even if the manner of executing the work cannot be determined in advance as to every part of the work, a different unit price should be made for the various classes of work. There is now a classification as to material excavated. It is just as easy to specify that the manner of doing the work shall be classified as the material.

How such discretion could be utilized collusively between dishonest officials and contractors can easily be seen. Is it wise to proffer such opportunities? This is not mere speculation. The prosecuting attorney in the Greene & Gaynor case, in his opening address to the jury, declared that just such provisions were used in the Carter frauds for corrupt ends. He said, as quoted in the Washington "Evening Star," January 28, 1906: "Carter at that time purposely and with intent to defraud in connection with the defendants, began to so change the requirements in the contracts as to leave it to the engineer officer as to which style of work should be required, rather than to permit bidders to base their proposal on the cheapest style."

General Comment.—The specifications are drawn with the evident intention of guaranteeing just as little to the contractor in the way of reliable information as can be given and to leave the engineer or any of his authorized assistants or inspectors with almost autocratic authority over the work.

Certainty is the most important thing to a contractor. Let him know what he is going to bid on and then the government will get from the best contractors exact, well-considered bids upon which the work can be completed without friction or controversy.

Such specifications lack in a marked degree the element of mutuality which is the foundation of all contractual relations. They are one-sided.

At this time the whole western country is busy with railroad construction under contracts which are drawn after conference with experienced contractors as to how the work is to be done. Experienced and responsible contractors, who, by reason of their ability and resources, have achieved success, readily command private work on fair terms. It is not surprising that such contractors do not regard government contracts under such specifications as very important or even desirable to secure.

One of the Oldest Canals in the country is attracting considerable attention just now in Delaware and Maryland on account of the petition of its owners to the Legislature of the latter State for the right to charge passenger tolls. It is the Chesapeake and Delaware Canal, 13⅝ miles long, between Delaware City and Chesapeake City. It was chartered in Maryland in 1799 and in Delaware some years later. Construction was begun in 1824 and completed in 1829, and since then it has been in constant use. The engineer of the work was Benjamin Wright, well known to students of early American engineering, and he accomplished a very creditable undertaking, with many heavy cuts and embankments. The canal is 66 ft. wide on the water line, 36 ft. at the bottom and is about 10 ft. deep. The locks are 100 ft. long and 22 ft. wide. It is navigated by a regular steamboat line as well as by other vessels, and last year about 20,000 passengers are stated to have been carried over it. The proposition to pay passenger tolls is being opposed by the shipping interests and residents in the vicinity, which in itself is an indication that the waterway has not outlived its usefulness. The canal cost $2,250,000, of which $625,000 was furnished by the United States, Pennsylvania, Maryland and Delaware and the remainder by private parties.

Steel Piling Foundations.

In putting in the foundations of the new Hotel Brevoort in Chicago some serious difficulties have been encountered, chiefly because of the necessity of sinking deep caissons next to a very high building, the Tacoma, and also because of the unusual depth for a subcellar in the rear half of the hotel, which also abutted against the foundations of other buildings not quite so heavy as the Tacoma.

The foundations adjoining the Tacoma were first piled with steel sheet piling, made by United States Steel Piling Co., to a depth of 30 ft. or thereabouts before excavating, and when excavated to that depth, the pits were continued to their full depth in the ordinary way, that is, by the use of wooden sheathing or laggings in short lengths. The steel sheet piles were driven first as a precautionary measure against the lateral pressure from the heavy Tacoma building, prior to any excavation. In the rear or subcellar part the entire cellar wall and foundations extending beside the old adjoining buildings were first enclosed with a continuous row of the same steel piling before excavation, and the pits for the bearing piers were sunk within the steel pile walls, using the wooden laggings.

Five-Foot Column Caissons of Steel Piling at Brevoort Hotel.

The steel sheet piling was thus used in two ways, first, adjoining the very heavy Tacoma building for the first or upper 30 ft. only of the piers; second, for the walls of the deeper, subcellar portion only, the adjoining buildings not being so heavy, and to a depth of only about 16 ft. Elsewhere, wooden laggings only were used for 46 piers, varying from 4 ft. 6 in. to 7 ft. 6 in. diameter. In all these cases the wells were dug clear through the soft, wet clay which underlies so large a portion of this city, and almost the entire central business portion where most of the large business structures are erected.

The average depth of the piers is about 82 ft. below street grade. The load on the concrete which forms the filling of the caissons is about 18 tons, not exceeding 20 tons, per square foot, and the load on the hard gravelly clay, designated hard-pan, underlying the soft clay, is somewhat less than 4 tons per square foot.

All the adjoining buildings were placed on jacks during the process of sinking the new foundations, and the settlements were closely noted and taken up from time to time. The Tacoma foundations settled during the process 2½ in. or thereabouts, and the other buildings rather less, but, thus far, there are no perceptible movements in any of the superstructures. One building, a theater, has been held on jacks along the entire length of the Brevoort building, and a party foundation on caissons is being built, as the intention is to take down and rebuild the theater or build a typical high building on its site in the near future.

No difficulty was experienced in driving the steel sheet piling along the straight foundation walls, in the rear, but there was some trouble in driving them on the circular scheme next the Tacoma. Two of these caissons deflected so much that it was necessary to sink a cast-iron column within each so as to get the load on the center of gravity, but this was not a difficult matter. An ordinary pile driver was used, but it is believed that with some changes in the apparatus, a much more accurate result in driving the circular caisson sheeting could be secured.

In sending this information Messrs. Egan & Prindeville, the architects, give credit for the planning of these foundations to Messrs. Purdy & Henderson, their engineers.

An Apprentice School has been organized at the West Lynn shops of the General Electric Co., for boys at least 16 years old, having a grammar school education. The apprenticeship lasts four years and aims to teach the boys to become machinists, tool makers, pattern makers and carpenters, moulders, instrument makers and electrical workers. In addition to this trade training, the school teaches the usefulness of grammar school education in the works management and other subjects which will fit the boys for leading factory positions. The instruction period lasts three years, beginning six months after the apprentice work and ending six months before its close. It will be noticed that this system of apprenticeship is, in effect, the same that exists unnamed in small shops, where the employer personally assists his brightest young men in various ways to acquire the education and trade knowledge required in responsible positions.

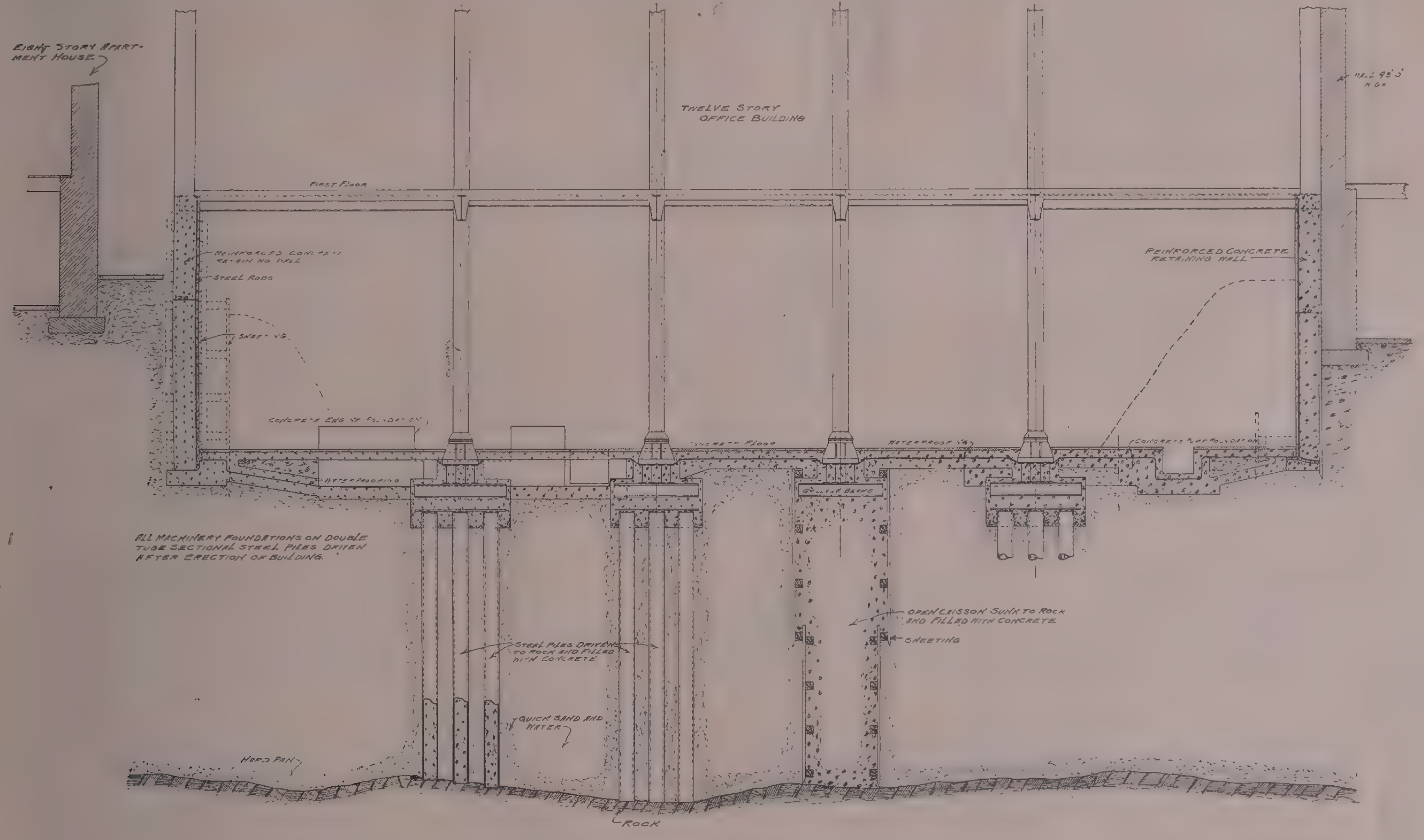
Building and Machinery Foundations in Quicksand.

The 75x99-ft. Knickerbocker Building at Nos. 114 and 118 West 39th St., New York, is a 14-story steel cage office building which occupies a site previously covered by several low brick buildings. Adjacent to it and extending to the lot lines are the six-story Hollywood Hotel, the 125-ft. brick stack of the New York Telephone Co.'s building, and the tall Knickerbocker and Casino Theatre buildings.

Soon after the old buildings were removed the site was excavated to a depth of about 18 ft. below the curb, except along the sides and rear, where were left banks of earth from 3 ft. to 8 ft. in width and having slopes of about 1 to 1. The tops of these banks were 6 ft. to 10 ft. below curb level, varying with the depths of adjoining walls.

The footing of the wall of the hotel was found to extend about 7½ ft. below curb level. For the major part of its length this wall stands 4 ft. back from the lot line. The nearby wall was constructed in a trench extending about 13 ft. deeper than the hotel wall. The latter was not shored.

Two rows of 2-in. special sheet piles were set up 4 ft. apart and were driven by a pneumatic hammer operated by two men. The sheet piles were made tight before any driving was done. The two rows were kept at a uniform distance apart by means of walings and cross braces. Outside walings were also used to support the row of sheeting farthest from the hotel. These walings were bolted to timber piles driven in a row parallel to the trench and spaced about 9 ft. Each pile was supported by two braces running back either to completed interior piers or to timber footings of ample area. In the bottom of the trench was constructed a concrete footing extending 22 in. inside the lines of inner face of proposed wall, a space sufficient to provide for lap of water-proof layer and for key to resist tendency of the wall to slide inward on the footing. One side of the wall form was erected on the line mentioned above. The other side was formed in part by the inner faces of the walings. The remainder of the needed surface was formed of 2-in. planks on furring strips. The space back of the planks was packed with gravel and dry sand. A thick layer of water-proof material (felt and pitch) was carried across the top of the concrete footing and up the outer wall of form to the under side of the lowest tier of cross braces. The space devoted to the wall had a width of 20 in. A row of 1⅛-in. round steel bars spaced 6 in. was set up in the form. The bars stood in a 2-in. channel bar placed on the water-proofing. The centers of rods were 2 in. from the face of the proposed wall. The concrete of the wall was deposited in courses as fast as braces could be shifted and water-proofing applied to the outer wall of the form. The reinforced concrete extends to the level of the tops of first-story floor beams, the ends of which are imbedded in it.


EIGHT STORY APARTMENT HOUSE
TWELVE STORY OFFICE BUILDING
WALL 93'0" HIGH
FIRST FLOOR
REINFORCED CONCRETE RETAINING WALL
STEEL RODS
SHEETING
CONCRETE ENGINE FOUNDATION
WATERPROOFING
CONCRETE FLOOR
WATERPROOF
GIRDER BEAMS
CONCRETE PUMP FOUNDATION
REINFORCED CONCRETE RETAINING WALL
ALL MACHINERY FOUNDATIONS ON DOUBLE TUBE SECTIONAL STEEL PILES DRIVEN AFTER ERECTION OF BUILDING.
OPEN CAISSON SUNK TO ROCK AND FILLED WITH CONCRETE
SHEETING
STEEL PILES DRIVEN TO ROCK AND FILLED WITH CONCRETE
QUICK SAND AND WATER
HARD PAN
ROCK

General Construction of Foundations of Knickerbocker Building, New York.

On the opposite side of the site, adjoining the Casino Theatre building, a similar wall was built in sections about 8 ft. in length. The trench extended 6 ft. 8 in. below the footing of the theatre wall. As before the rows of sheet piles were 4 ft. apart, the back row resting against the adjoining wall. The bank of earth along this side of the site was of such width that round piles were not needed to support outside walings, which were held in place by braces from the bottom of the lot, until such time as two or more sets of the interior walings had been sunk below the surface, when the exterior braces and waling would be removed. The water-proof layer extended the entire length of every section while the concrete stopped 8 in. short of the ends, thus providing room for a lap in the water-proof layer. Alternate sections were constructed, all with V-shape, vertical grooves in the ends. The concrete was built up in layers corresponding in depth to the spacing of the walings. The hardened concrete was braced against the front row of sheeting by means of wedges, braces and secondary walings before removal of the set of walings just above the concrete and separating the two rows of sheeting. Upon completion of the sections to the proper height for receiving first-story floor beams, heavy braces were wedged between completed interior piers and the reinforced concrete wall, the ends against the latter being placed somewhat below the first-floor level. The wall braces on both sides of the site were left in position until the steel work of the first floor was completed. Across the site, between interior piers, beams or struts of reinforced concrete were constructed at a depth sufficient to clear the many trenches to be provided in the cellar floor, to which reference will be made further on.

When a little more than half the wall was in place the gaps in it were filled in. The sheet piles along the sides of the excavations sunk for this purpose were fitted to those at the corners of the pits previously sunk. The sheeting in the ends of the latter was removed and the water-proofing of the latter section joined to that of the two older ones on either hand.

Owing to the pressure transmitted through the soil and due to the wall alongside, which is 93 ft. high, the two lower sets of walings were spaced only 2 ft. centre to centre. Owing to lack of space, for workmen, in the pits, the footing was made but 1 ft. deep. Its top surface pitched downward toward the back face of the wall. Bricks which had been thoroughly dried were laid in pitch to form the water-proof layer on top of the footing. This work was carried to a line above the position of the lowest set of walings, where a change was made to felt and pitch; this kind of water-proofing was continued to the first-floor level. As soon as the new wall reached the level of the footing of the theatre wall the back sheeting was cut off and the water-proof layer carried from the sheeting, which served as the back of the form, to the face of the theatre wall.

A bed of quicksand was found to extend from the bottom of the main excavation to bed rock.

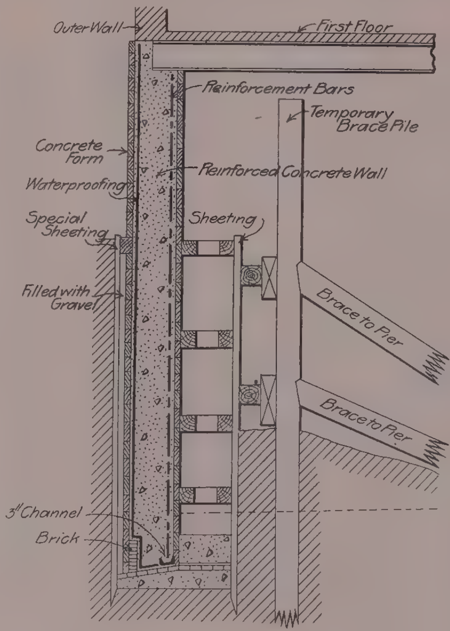
Its depth varied from 10 ft. to 25 ft. owing to the uneven surface of the rock. The foundations of the column and wall piers consist of clusters of tubular steel piles 12 in. in diameter and ⅜ in. thick sunk to bed rock and filled with concrete. Under columns there are twenty groups of piles as follows: Four groups of five piles, eight of six, six of seven and two of eight. In the wall piers there are ten groups, two of which have five piles each, six have six piles and two have seven piles each.

The piles for interior piers were driven with an ordinary drop hammer machine assisted by a water jet. The hammer delivered blows to a drive-head about 7 ft. long made of very heavy pipe of the same diameter as the piles and provided with an extension sleeve engaging the pipe for a distance of 1½ ft. A heavy drive-ring topped the special section, which was provided with a slot through which the interior jet pipe was worked. A short distance below the slot was an opening for the discharge of material washed from the piles. Such material was conveyed, at times, to other parts of the site through hose 6 in. in diameter. The jet pipe was provided with a perforated chisel instead of an ordinary nozzle. The combined action of the chisel and hammer was sufficient, at times, to cause the entry of the pile into soft rock a distance of 2 ft. or more. Water was not always forced through the jet pipe during the time of sinking the pile. When driving had been completed and only water remained inside the pile, the hose supplying the jet pipe was attached to a closed tank partially filled with rich grout under air pressure. On opening a special valve on the tank the pile was filled with grout, from the bottom. The jet pipe was then removed and washed gravel deposited in the pile; this caused the grout to overflow at the discharge opening. The surplus grout soaked into the ground around the pile. The drive-head was now removed and another pile, to which a second drive-head had been attached, hoisted into place on the machine. The tops of the piles composing a group were joined by means of a block of reinforced concrete which was finished to the proper level for receiving the steel grillage.

Employing usual forms of construction, the columns in side walls and rear wall would have rested on cantilever girders. In the Knickerbocker Building all wall piers rest on two rows of staggered steel piles. The grillages supported on these piers are 28 in. wide. There are no party walls on the site. The back row of piles in a wall pier are sunk 3 in. from the wall of abutting building. The number of piles in the back row is greater than in the front row; at the same time the line joining the centers in the back row is nearer to a parallel line through the column center than is the line through the centers of the front row. The division of piles between the two rows and the spacing relative to the column center are so adjusted as to divide the total load equally among the several piles.

The use of the narrow pile piers just described, in place of cantilever girders, would not have resulted in any saving of time or money had any but tubular piles been employed, because the shoring of the abutting wall would have been a condition precedent to the introduction of other adequate supporting means. The tubular piles were driven in the bottoms of pits which had been sunk in the manner already described. After a number of cross-braces had been inserted between walings, short sections of the back walings were cut out. The gaps thus formed permitted the proper placing of the piles composing the back row. The piles of wall piers were driven with a special driver that worked close to the wall of adjoining building, without producing injurious vibrations. This machine consists, essentially, of a hollow piston, fixed relative to the pile, and a weighted reciprocating cylinder, together with the necessary valves, and a base which caps the pile and maintains the driving apparatus in position, without the use of guides or other framework. An essential feature is a movable anvil or follower block, inside the base, which freely follows the pile under the impact of the hammer cylinder and thus delivers the full blow to the pile, without reactions unfavorable to efficiency. The piston is made hollow to permit the free use of the jet pipe already described. The hammer is operated by steam or air, preferably the latter, at a pressure of 70 lb. or more. It delivers about 275 blows per minute. The stroke is 5 in. The weight of the machine is about 1,200 lb. Its height is 3½ ft. A gin pole or light hand-power derrick is used in handling the hammer.

The work done by the two kinds of hammers was done under conditions so dissimilar as to make a comparison of costs impossible. The pneumatic hammer was not available early enough for a trial on the interior piers. In some situations where the pneumatic hammer was used, the ordinary machine could not possibly have been employed. Less time was consumed in moving the former, but the rate of sinking, under its action, was naturally lower than that observed under the blows of a drop hammer.



Wall Foundation.

The wall columns and grillages supporting them were set as soon as the concrete pier cap was in place and covered by the water-proof layer. A section of concrete wall was carried up to first-floor level as soon as a wall column was in place and securely braced.

As soon as the first-story steel work was in place, work in the cellar was resumed. Besides the cellar floor there remained to be constructed foundations for a plant designed to provide heat, light, power and ventilation for the new building and others owned by Mr. R. W. Goelet and situated on the same block. It proved necessary to construct special foundations for all the machines except light ones, which are supported by the cellar floor. The plant includes a Corliss engine and a crank and fly-wheel pumping engine. Through the middle part of the cellar from front to rear, the floor and necessary foundations were constructed, after which the banks of earth remaining in front of the side walls were removed, in sections, and strips of floor completed from wall to wall. The floor is much cut up by trenches for water mains, drips and exhaust lines. There is also a pump pit and two small pits for the accommodation of plunger lifts. One of the four elevators with which the building is equipped runs to the cellar and is provided with a pit 3½ ft. deep. Conduits for electric mains also extend through the cellar floor. The pump pit was made by lining a steel tank with reinforced concrete. Back of the latter runs the water-proof layer, which extends under all trenches and under or through all foundations. This layer is continuous with the water-proofing on the outside of cellar walls. The sidewalk vault is reserved for the storage of coal. Four large steam boilers are located between the front row of columns and the second row. Near the boilers a sump was built, from which tile drains, with numerous branches, were extended to the cellar walls. The drains lessened, materially, the difficulties incident to the construction of the floor, which has proved to be water-tight. Some trouble was experienced in excluding fine sand from the drains. Access to the sump is had through a manhole in the cellar floor. The concrete under and alongside longitudinal trenches was much thickened and heavily reinforced.

Foundations for pumps, tanks, boilers and generator sets were made by sinking sectional steel piles, which were filled with concrete. The piles extended to bed rock and were double. The diameters of the two pipes were about 6 in. and 5 in. The annular space between the tubes was about 0.15 in. This spacing was maintained by means of steel balls sunk in hemispherical holes in the surface of the inner tube. The sections were 6 ft. long and broke joints 3 ft. Three balls were placed at equal distances about the inner section near either end and on either side of the joint position of abutting outer sections. The lower end of the pile was formed of a full section of outer tubing and a half section of inner tubing. By using a temporary half section of pipe at the top, when driving, the constant lap of 3 ft. was maintained. All pile sections were delivered at the site with both ends faced at right angles to the axis of the pipe.

All of the sectional piles were driven with the pneumatic hammer already described. In setting the machine at work on a pile of a diameter different from the one last driven, the ring which filled the annular space between the latter and the cap embracing the same is removed and another inserted. The function of the ring is to fill the space between cap and pile in order that the machine may be centered on the pile and held securely in position. The cap fixes the upper limit of pile diameters. The lower limit is 5 in.

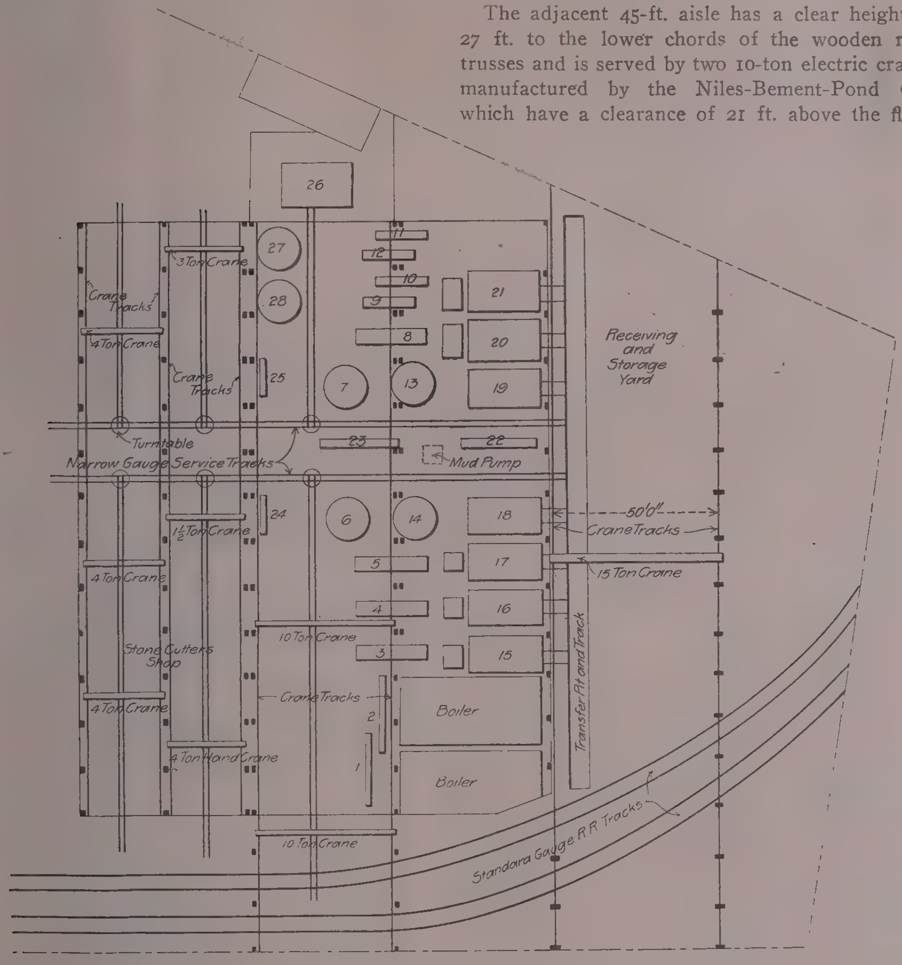
A few of the machines included in the plant have fly-wheels so large as to require pits which extend below the cellar floor. The foundations of such machines and a few others were reinforced with steel bars. Round bars were used exclusively on the Knickerbocker site.

The architects of the building were Messrs. Schickel & Ditmars. Mr. Ira Watts was the consulting engineer for the owner. M. Reid & Co. were the general contractors and Clark & Co. the contractors for the pile and concrete work.

Oiled Roads are being investigated by the Kansas Agricultural College, in order to ascertain whether the Kansas oils can be used for highway work. About a quarter of a mile of sand road near Hutchinson has been sprinkled with 4,000 gal. of oil, the roadway being 32 ft. wide. A gumbo road at Manhattan has also been treated. The heavy black soil was first loosened to a depth of 4 in. and pulverized with disk harrows. An inch of the coarsest sand obtainable was then spread over the top and three applications of oil made. The oil is the residuum after removing kerosene and gasoline. Both roads are still in the experimental stage.

Marble Cutting for the New York Public Library Building.

The $3,000,000 Public Library Building which is now being constructed at Fifth Ave. and 42d St., New York, will contain about 500,000 cu. ft. of white marble. The marble is of a very fine uniform texture from the quarries at Dorset, Vt., and is shipped to New York City on flat cars. Except the large pieces required for columns and other special purposes it is received in rectangular blocks of from about 10 to 50 cu. ft. and all pieces are cut to dimensions and polished, carved and finished on one or more sides at a shop established for the purpose at Port Morris in the Borough of the Bronx, New York, by Norcross Bros., the general contractors for the building. The building was erected early in 1902, and was equipped with a complete and abundant installation of improved machinery for this class of work. It corresponds essentially with several other plants established by Mr. Norcross at Providence, R. I., at Marblehill, Ga., Tuckahoe, N. Y., Cleveland, Ohio, and a brown stone plant at East Long Meadow, Mass. Some of these plants are intended for general stone cutting, some are adapted for interior work and this is more especially intended for a majority of exterior work. It therefore serves as an illustration of the arrangement and methods for cutting high grade structural stone work of uniform character in large quantities.



Location of Tools in Marble Cutting Shop.

Quarried stone is received on two tracks from the Port Morris branch of the New York Central & Hudson River R. R., entering the yard on a curve and crossing from side to side at one end of the building, as indicated in the general plan. The tracks are crossed by a 15-ton electric girder crane of 50-ft. span and 20-ft. clearance above the ground, manufactured by the Niles-Bement-Pond Co., and traveling from end to end of the yard adjacent to the side wall of the shop. This crane unloads the marble and stores it in the stock yard between the tracks or delivers it to the narrow gauge surface tracks running transversely through the shop, and to the cars on a transfer track that serve the principal gang saws. The yard crane also unloads coal, sand and other supplies required by the plant. All work is done inside the 132x175-ft. shop, which has a wooden roof and walls and is divided by rows of longitudinal columns into four aisles. The first aisle, 35 ft. wide and 16½ ft. high in the clear below the roof trusses, is adjacent to the transfer pit, and is chiefly occupied by the gang saws, steam boilers, power and electric plant. This aisle has a flat roof with untrussed transverse wooden beams intermediately supported by vertical posts. It is not equipped with traveling cranes but depends on stationary jib cranes for the service of its tools.

The adjacent 45-ft. aisle has a clear height of 27 ft. to the lower chords of the wooden roof trusses and is served by two 10-ton electric cranes manufactured by the Niles-Bement-Pond Co., which have a clearance of 21 ft. above the floor and travel from end to end of the building on 12x12-in. wooden girders supported on 10x12-in. wooden posts in the planes of the regular transverse bents 15 ft. apart. In this aisle are located most of the smaller machines and rubbing beds, and all other machines are placed in the side wing. They are arranged near one side of the aisle, many of them being placed between the columns so as to leave as much floor space as possible vacant for handling the marble and for hand work on it. The two side aisles are 26 ft. wide, and from 17 to 20 ft. in clear height and are covered with a lean-to roof supported on transverse untrussed rafters carried by 10x10-in. longitudinal wooden girders on vertical wooden brackets supporting in each aisle the 10x10-in. longitudinal wooden girders for the traveling cranes. In one aisle there are three 4-ton cranes operated by hand, in the other aisle there are two 1½-ton and one 3-ton cranes with hoists made by the General Pneumatic Tool Co. There is also one 4-ton hand crane in this same aisle. These cranes and the narrow gauge surface tracks parallel with them serve the stone cutters who occupy the two aisles exclusively for hand work.

In general the marble is delivered by the stock yard crane to the transfer cars which carry it to the gang saws where it is handled by stationary derricks and whence it is moved by the transfer cars and on the transverse surface tracks to the middle aisle and distributed longitudinally by the traveling cranes to the rubbing beds, planers, headers, lathes and polishing machinery. After the machine work is completed the stone is again handled longitudinally by the tracks on the floor to the traveling cranes in the two side aisles by which it is distributed longitudinally throughout the shops to the large force of hand workmen who finish, dress and carve it. When completed the marble is sent out of the shop by the surface tracks or by the cranes in the center aisle, which have long runways extended through the yard across the railroad tracks to provide for loading the material on cars and trucks for shipment to the library building.

All machinery is of standard or improved design and is arranged as indicated by the reference numbers in the accompanying plan. Some of the larger machines are operated by individual motors made by the General Electric Company. The remainder are driven by belts from a main shaft extending through the roof trusses from end to end of the building close to the center aisle columns. Power is furnished by a 300-h.-p. Atlas engine and two 300-h.-p. Atlas boilers. Compressed air is furnished by an Ingersoll-Sergeant air compressor, and there is a 75-h.-p. General Electric dynamo furnishing the current for the traveling cranes, for the diamond saw machines, for the fans providing blast for four forges in the smith shop, for six arc lamps and a large number of incandescent lights. Boiler feed water is taken from the city mains and water for the machines is pumped from an artesian well to a roof tank. There are no skylights but the shop is lighted through large areas of wall windows, and in summer through the open sides where sections of the sheeting are temporarily removed. In winter heat is provided by two lines of horizontal steam pipe coils extending from end to end of the building and attached to the upper parts of the center aisle columns so as to give clearance for passing underneath them. The shop is not floored and the foundations of the heavy machines are made with concrete and timber bases seated on the soil a short distance below the original level surface.

The machines designated by the reference numbers are as follows:

No. 1, Preston Machine Co.'s lathe, 20 ft. long, 48 in. swing; capable of finishing a 24-in. column 15 ft. long in one week.

No. 2, 18-in. header built by the Young & Farrel Machine Company, Ansonia, Conn., and erected by Daniel H. Hunt, New York; used for making moldings; cuts on both direct and return strokes.

Nos. 3, 4, 5, 80-in. Hunt planers used for moldings. Both header and planers are used to make an accurate bed face after the stone has been hand dressed or comes from the gang saws.

Nos. 6, 7, rubbing beds, 14 ft. in diameter, manufactured with under drive by F. R. Patch, Rutland, Vt.

No. 8, Patch 12x6x14-ft. planer.

Nos. 9, 10, 11, Single 12x3x3-ft. planer manufactured by the Lincoln Iron Works.

No. 12, Patch 8x3x3-ft. single planer.

Nos. 13, 14, Lincoln 12-ft. rubbing bed.

Nos. 15, 16, Lincoln 10x7x7-ft. gang saws with double pitmans.

Nos. 17, 18, Patch 10x8x7-ft. double pitman gang saws.

No. 19, Lincoln 12x8x7-ft. double pitman gang saw.

Nos. 20, 21, Patch 15x8x7-ft. and 16x12x7-ft. double pitman gang saws.

No. 22, Lincoln iron frame 12-ft. rip saw.

No. 23, Straight cut diamond saw with 12-in. blade, manufactured by Willard Meyers, Long Island City, N. Y., and having a capacity of 24 in. per hour.

Nos. 24, 25, Meyer's 60-in. circular saws with a capacity of 4 in. per minute.

No. 26, Double blade 60-in. circular diamond saw manufactured by the Geo. Anderson & Co., Comoustie, Scotland, capacity 12x12x2½ ft. stone, speed 5 in. per minute.

Nos. 27, 28, Patch 13-ft. rubbing beds. In the stone-cutting aisles there are about 100 pneumatic tools supplied by H. C. Kotten and J. H. Dallett, and operated by air at 100 pounds pressure delivered through two-way openings 14 ft. apart in a pair of 4 in. longitudinal mains running through the side aisles.

The gang saws each have a large horizontal frame suspended over the bed by means of four inclined arms engaging an upper horizontal rocker shaft perpendicular to the vertical planes of the saw blades. The rocker shaft is driven by two connecting rods from the main shaft eccentrics and causes the frame to move back and forth with a pendulum motion and an 18-in. stroke. It is simultaneously fed downwards at an average rate of about 3 in. per hour by means of vertical screws and nuts operated by an adjustable ratchet device connected with the pitmans. The straight horizontal saw blades are set in the reciprocating frame in groups of two or more and may be spaced as close as 1½ in. apart over the bed which is about 6 ft. wide and 12 ft. long. The blade cuts with sand which is continually delivered to the work suspended in streams of water which flow over the surface of the stone and into the cuts.

When operations are commenced about a bushel of sand is shoveled by hand on the surface of the stone and is washed over it and to the cistern below by the feed-water. This water is agitated and is raised by a special pump to a reservoir on top of the machine whence it flows by gravity through the distributor. After a time the sand is so thoroughly mixed with the water that it remains in suspension and passes over the work and through the pump and reservoir without requiring much addition. It is, however, carefully watched and more sand is thrown on if the water becomes too clear. The reservoir distributes the water across the full width of the machine so that it falls in a wide sheet over the entire face of the stone. The progress of the saws depends on the number of blades in use at once and varies from 2 to 4 in. vertical feed per hour. The machine makes 94 strokes per minute and 7 machines are operated by one man.

In order to secure an exact surface to cut the stone by, one side of each block is generally finished on the rubbing machine after it comes from the gang saw. This machine has a horizontal circular table driven by a vertical shaft and mitre gear making about 40 revolutions per minute. Two or three blocks are usually placed on this bed at once and held stationary by fixed stops which engage them. Their weight presses them against the face of the smooth table and in 5 or 10 minutes they are ground accurately by the action of the fine sand which is carried to any point of the table by means of an adjustable stream of water flowing through a trough filled with sand.

The consumption of sand for the gang saws and the rubbing machines is about 100 tons per month of a very fine quality brought from a pit in Long Island. From the gang saws the sand and water are delivered through pipes with a steep pitch to a 14x10 ft. cistern 8 ft. deep where the sand settles and the clear water overflows to the sewer. This cistern is provided with three partitions, two of them having passages for the water over their upper edges and the center one having a narrow passage between its lower edge and the bottom of the cistern, thus forming a trap with a settling chamber on both the outlet and the inlet sides of the cistern. By this means the water circulates up and down and back and forth and deposits a large quantity of sand which is cleaned out about once a week and is used over and over again in the gang saws. A much larger quantity of sand is required for the rubbing beds, and is collected in open gutters delivering to settling basins for each machine which are cleared out every few hours. From these basins the effluent water passes to the cistern described and deposits there a large part of the remainder of its sediment.

About 350 men are employed in these shops and have turned out as much as 6,000 cu. ft. of cut stone per week. Some of the stone is elaborately moulded and carved with a large amount of delicate hand work and when this is in the shop the product is, of course, less than above stated. The shops have been in operation about three years, and the work for the library building is about three-fourths finished. The plans were made in the Worcester office of the Norcross Bros., and the building was erected and the plant installed under the direction of Mr. Thomas O'Reilly, New York manager, assisted by Mr. H. E. Hayden as superintendent of construction. The shop is operated under the superintendency of Mr. W. T. Jeffers.

An African Railway Enterprise which is spoken of highly by Consul Hollis at Lourenco Marquez is the construction of a line from Lobito Bay to Buluwayo. A few years ago an English engineer secured a concession to build a railway inland from this place, which is about 20 miles north of Benguela, to reach some copper deposits. The British capitalists did not look with favor on the project, however, and it has now been revived on a different and larger scale by a Portuguese company, of which Col. Joaquim Jose Machado is the official head. Lobito Bay, although now so small as to find no place on most maps, is becoming of enough importance to have a regular line of steamers calling at it. Its harbor is said to be very good, requiring only a small breakwater to make it a perfectly safe port. The railway line will first run to the copper region and then swing to the south to Matabeleland, thus affording a shorter line to that region than the route from Cape Town. Col. Machado was the leading spirit in developing the port of Beira, and Consul Harris advises American manufacturers of railway materials for export to communicate with him at Lisbon.

Building a Marsh Highway Near New York.

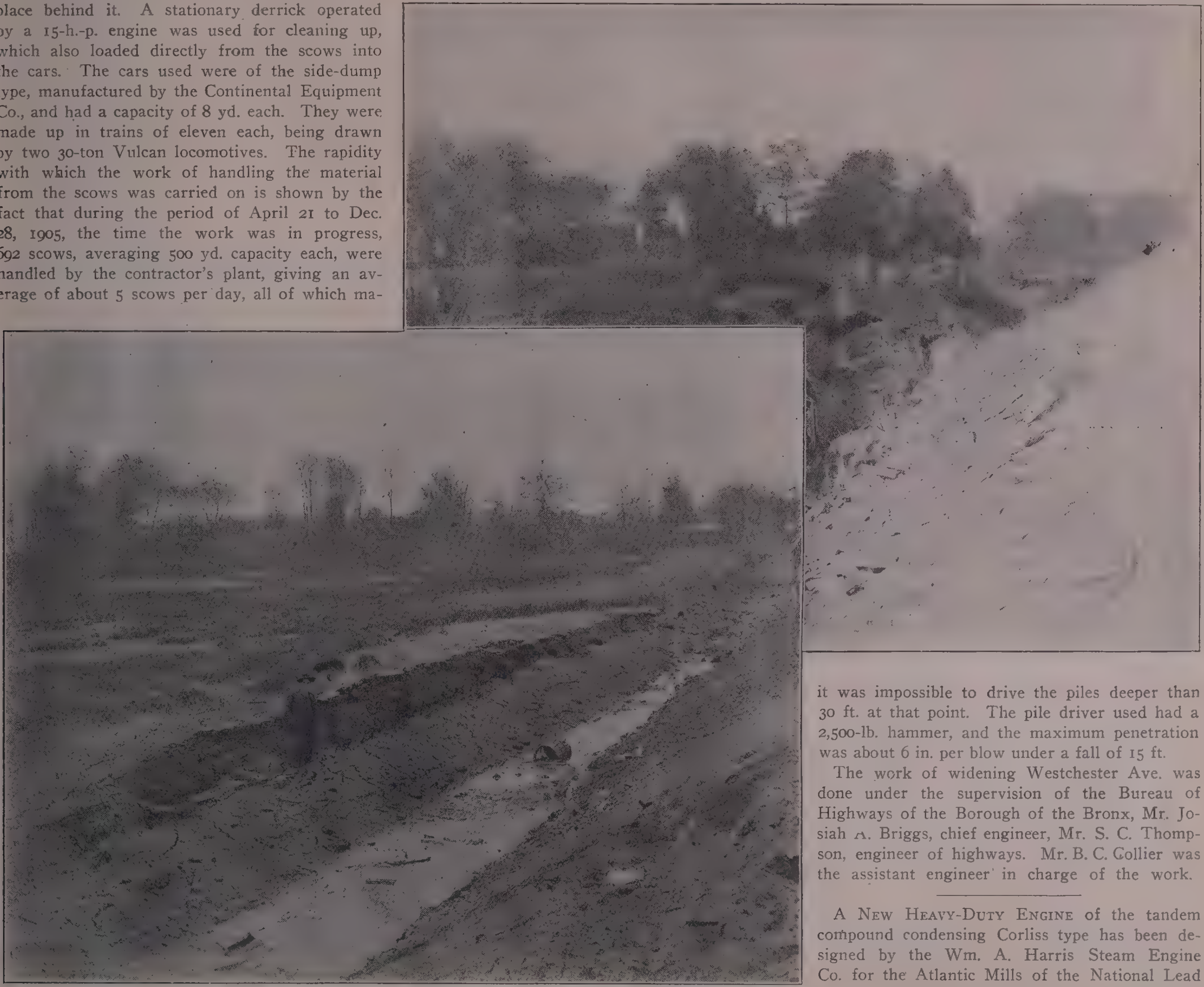
About two years ago an ordinance was passed by the City of New York authorizing the widening to 100 ft. of Westchester Ave. in the Borough of the Bronx, for a distance of 13,000 ft., extending from the Bronx River to the former village of Westchester. This street is what was formerly known as Westchester Turnpike, one of the early roads of Westchester County. It was originally 60 ft. wide except for a stretch of about 1,700 ft., where it crosses a salt meadow, where the width was but 25 ft. The contract, involving about $320,000, was let to Mr. John C. Rodgers. The work requiring most consideration was the filling in of that portion across the meadow which was begun April 21, 1905, and finished Dec. 28, 1905, during which time a total of about 350,000 yd. of material had been handled.

The salt meadow through which the road passes is a part of an inlet from Long Island Sound. It is covered largely by a turf about 1 ft. in thickness, underneath which is a mass of very soft wet material composed largely of peat and fibrous vegetable matter in various stages of decay. It was found on making soundings that this bed had a depth of 25 to 30 ft., and was so soft that after passing through the top coating of turf the sounding rods could be forced to the depth mentioned by the combined weight of three men pushing down on them. After reaching this depth the rods were driven with mauls until the resistance was such as to prevent their going further by this method. Wash borings made on adjacent streets since these soundings have shown the whole meadow to be underlaid by a stratum of very fine quicksand from 10 to 15 ft. thick. It was impossible to determine beforehand just what proportion of material should be allowed for sinkage in making an embankment on this marsh, and this uncertainty was provided for by a separate lump sum item in the contract on which the contractor bid $15,000.

View Showing Sinkage of Old Causeway Under Filling Material.

The material used in this work was secured from dumping boards located in various parts of the downtown section of New York, whence it was transferred in scows to a point on Westchester Creek near the site of the work. The contractors having charge of the excavation work in the city, from which this material was taken, preferred to allow its use in this way to sending it out to sea to be dumped, owing to the amount of time saved in hauling the scows back and forth. The scows were taken to the point mentioned and unloaded one day and returned to the dumping boards on the day following; the time required for dumping them at sea was about three days.

The nearest tidewater point at which scows could be unloaded was on Westchester Creek, about two miles from the site of the dump. Here a dock was built and from it to the roadway the material was carried in dump-cars on a temporary railway. On this dock was located a 75-h.-p. boiler and double-drum digger engine operating a Hayward orange-peel dredge having a capacity of 2½ yd. This dredger was originally designed for a digging scow and was guaranteed to dig 2,000 yd. per day. The scows were brought to one side of the dock and unloaded by this dredge into the cars standing at the other side of the dock. As soon as one scow was practically emptied by the large dredge it was drawn further along the dock for cleaning up and a loaded scow was brought into place behind it. A stationary derrick operated by a 15-h.-p. engine was used for cleaning up, which also loaded directly from the scows into the cars. The cars used were of the side-dump type, manufactured by the Continental Equipment Co., and had a capacity of 8 yd. each. They were made up in trains of eleven each, being drawn by two 30-ton Vulcan locomotives. The rapidity with which the work of handling the material from the scows was carried on is shown by the fact that during the period of April 21 to Dec. 28, 1905, the time the work was in progress, 692 scows, averaging 500 yd. capacity each, were handled by the contractor's plant, giving an average of about 5 scows per day, all of which material was used in making the meadow fill. The amount of material paid for as filling in this dump was about 135,000 cu. yd., the balance of the material sinking below the surface and was covered by the item of sinkage. The elevation of the surface of the finished roadway above the surrounding meadow is 14.5 ft. at the highest point. Crossing the meadow parallel to the roadway and within the extension area was a causeway built about 1845. So far as could be determined, this causeway was originally constructed of rock and earth fill on a brush mattress foundation. The sinkage, however, was so great as to necessitate extensive repair work every few years. On it the contractor's railway was located, the track being laid with 65-lb. rails, and supported on bents spaced about 15 ft. apart. The material was dumped from this track to the causeway below, the trestlework being allowed to stand as the filling progressed, and afterwards the tracks shifted as widening progressed. The depth of sinkage of this old road that took place beneath the weight of new material is shown in an accompanying cut, the level of the original causeway being shown at the right and the settlement at the left. Measurements made at one point showed the surface of the old causeway to have sunk 5 ft. The settlement is still more strikingly illustrated by the formation of mud waves extending out from the roadway 200 ft. on each side and having a height in places of as much as 10 ft.


Views Showing Mud Waves Formed by Sinkage of Filling Material.

At one point the old causeway had running beneath it a culvert which drained an area of 500 or 600 acres lying to the north. In widening the avenue it was necessary to reconstruct this culvert. The contractor was given the option of building the culvert before the filling was done at this point or of waiting until after the filling was completed. He chose the latter course, though the culvert, which is constructed of reinforced concrete on a pile foundation, was designed to withstand a hydrostatic bottom pressure of 2,000 lb. per sq. ft. had the former course been adopted. The culvert measures 8 ft. horizontal by 4 ft. vertical, inside dimensions, and is composed of 1:3:6 concrete, with Lehigh Portland cement and trap rock; the reinforcement being Johnson corrugated bars. The bars are spaced 4½ in. on centers in the top and bottom courses, and 12 in. on centers in the sides of the culvert. The culvert was constructed inside a cofferdam of wood sheet piling holding back the water, which had formed quite a lake after the old culvert had been covered up. The culvert is supported on a pile foundation, the piles having been driven to a depth of 45 ft. in places. At the south end of the excavation it was found that the old causeway, beside sinking under the weight of the filling, had shifted to such an extent that it was impossible to drive the piles deeper than 30 ft. at that point. The pile driver used had a 2,500-lb. hammer, and the maximum penetration was about 6 in. per blow under a fall of 15 ft.

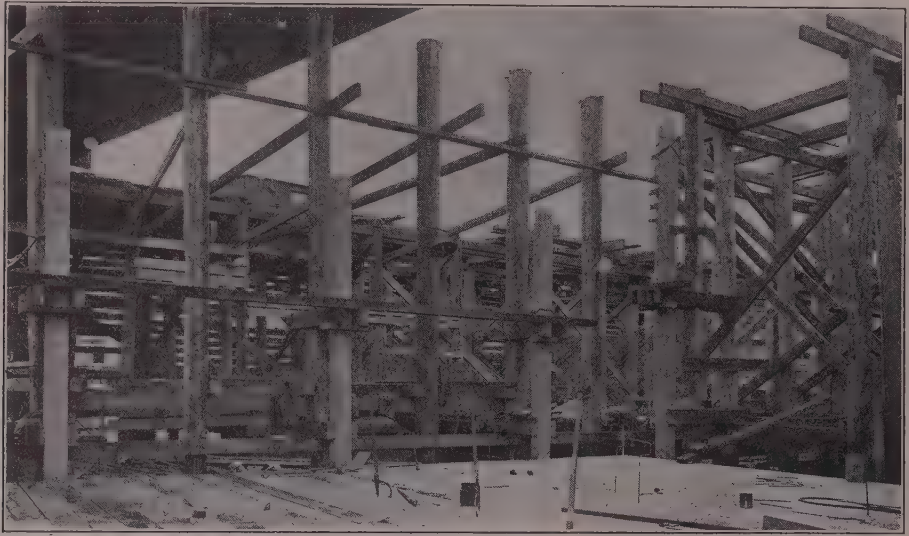
The work of widening Westchester Ave. was done under the supervision of the Bureau of Highways of the Borough of the Bronx, Mr. Josiah A. Briggs, chief engineer, Mr. S. C. Thompson, engineer of highways. Mr. B. C. Collier was the assistant engineer in charge of the work.

A New Heavy-Duty Engine of the tandem compound condensing Corliss type has been designed by the Wm. A. Harris Steam Engine Co. for the Atlantic Mills of the National Lead Co. It is intended to run at 100 r.p.m. with a steam pressure of 150 lb. at the throttle. The cylinders are 18 and 36 in. in diameter and the stroke is 42 in. A 600-kw. generator will be mounted directly on the main shaft, and at the extreme outboard end of the shaft there will be a heavy friction clutch. The shaft is 19 ft. long and 18 in. in diameter where the 60,000-lb. flywheel and generator are mounted; at the main bearings it is 16 in. in diameter. Owing to the character of the service the engine must perform the pillow blocks are provided with both vertical and horizontal adjustments. The valves are double-ported and operated by three eccentrics, one for the steam valves, one for the high-pressure exhaust valves and one for the low-pressure exhaust valves. The Brown valve gear is used, without wrist plates, and a new form of unhooking device is employed.

The New Portland Bridge.

By H. A. Crafts.

The bridge across the Willamette River at Morrison St., Portland, Ore., which was recently rebuilt, is the most important artery of commerce and travel between the eastern and western parts of the city. The old bridge consisted of four combination spans and a steel draw 308 ft. in length. It was built in the early eighties, and had become inadequate to the increased demands placed upon it in late years. The construction of the new bridge involved some difficult engineering problems. The point was to remove the old structure and build the new, and at the same time cause no serious interruption of traffic. In the second place there was the navigation of the river, which it would not do to interrupt for any considerable period. There was a depth of water in the main channel of about 60 ft. at low water and this tended to complicate the situation. It was estimated that there were not less than 30,000 persons crossing the bridge daily, and between 700 and 800 street cars, to say nothing of the general traffic crossing and recrossing the bridge.



Timber Grillage Platform used in Constructing Turntable Pier.

The contract for the work was let to the Pacific Construction Co., of San Francisco, in November, 1903, and work was begun in January, 1904, and was completed in February, 1905. The new bridge is a steel structure consisting of a 200-ft. skew span at the west end, a 384-ft. draw span and two 269-ft. common spans. The piers beneath the fixed spans are Cushing piers, the cylinders being 14 ft. in diameter up to above low water mark and 9 ft. in diameter in the top section. The center pier, which was in 60 ft. of water at the river's lowest stage, is composed of a foundation of 256 piles, which were driven with a 4,600-lb. hammer to depths varying from 33 to 48 ft.

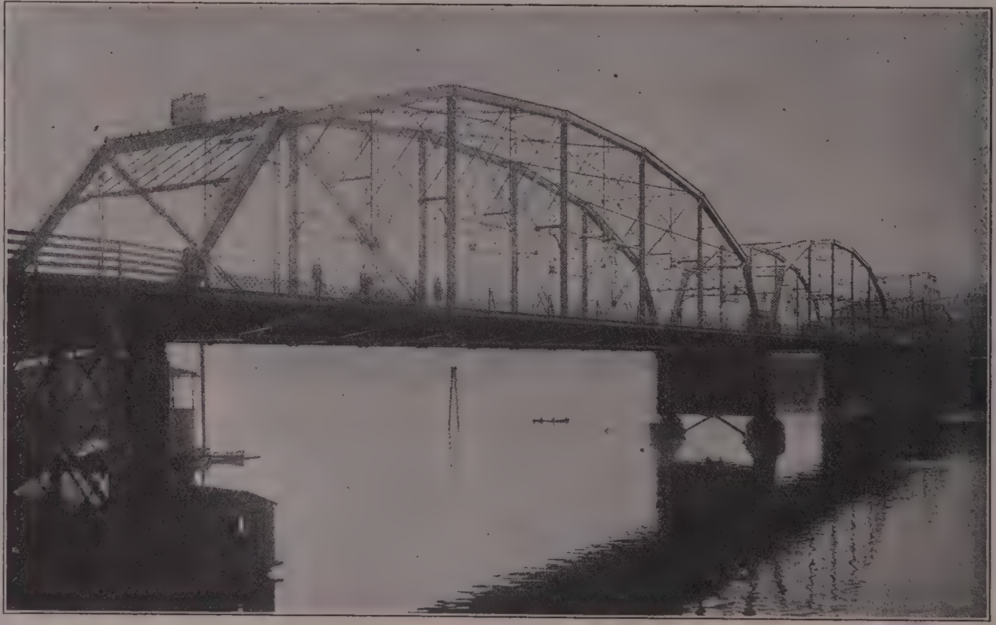
The cutting off of these piles and the building of the pier were among the more difficult problems encountered in the work. In order to insure stability for this pile foundation it was desirable to cut the piles off as close to the bottom of the river as possible. At the same time it was absolutely necessary that the piles be cut to a true level. To perform this difficult task the constructors designed a rig consisting of a carriage running on tracks, built upon solid false-work, on which was placed a second carriage working across the first. Suspended from this upper carriage was a four-post steel frame built of angles and rods, extending down to the required depth, and upon one corner of which was carried the shaft to which was attached a 5-ft. circular saw. This saw was operated by an electric motor, and by careful operation the piles were cut off to a true level.

Upon the top of this pile foundation was placed a grillage made of surfaced 12x12-in. timbers, the lowest courses being built up solid and thoroughly bolted together with screw and drift bolts. The main parts of the grillage were built on ways on shore, launched and lowered to place. After being located, piles were driven around this foundation, to which were attached 12x12-in. spuds, three on each side, and these were so arranged as to hold the grillage in exact position and to guide it as it was lowered to place.

This timber base was 51 ft. square, and after the base was in place open courses of 12x12-in. timbers with openings about 9 in. wide were laid and securely drift-bolted, one course to another. As it was built up this whole mass was submerged by loading it with gravel, the three top courses and three base courses being solid.

This timber grillage reached within three feet of low water mark. On top of it was placed a steel cylinder 46 ft. in diameter and about 30 ft. high. This cylinder was filled with concrete and now carries the turn-table machinery.

In removing the old fixed spans and erecting new ones a six-post traveler was used, the material being brought to the site on cars from a storage yard on a railroad switch some six blocks away.



New Willamette River Bridge, Portland, Ore.,

Extraordinary measures were taken by the constructors to permit the passage of cars during the process of construction, which made it necessary to raise the tracks over the falsework for the fixed spans some 6 ft. and providing an incline from the old draw span for the operation of the cars. This was done so that the new floor beams might be placed in position, the new floor being some 4 ft. higher than the old one.

In order to construct the westerly span without stopping traffic it became necessary to cut off 40 ft. of the old draw span. This was done during one night and the connection made and the draw operated in this shape for a considerable period, being kept in balance by counterweights.

It was the original design of the contractors to cut off 70 ft. of the easterly end of the old draw so as to permit the building of the center pier top without interruption of traffic; but in consequence of an objection coming from the United States government the city permitted the closing of the bridge to traffic for 42 days, during which time the the old draw was removed and the new one constructed.

The U. S. government also required that all old piers that had been built of stone on pile foundations be removed to a depth of at least 30 ft. below low-water mark. This was done by the employment of divers and heavy floating steam derricks. Navigation of the Willamette River was not closed at any period during the entire work of construction.

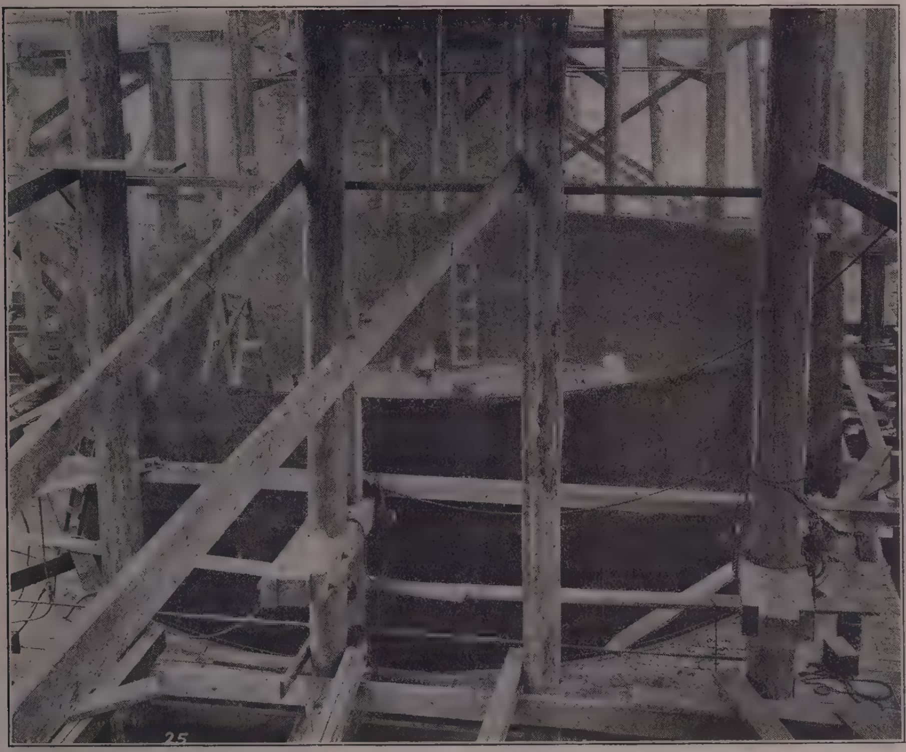
The old bridge had a roadway 21 ft. wide, and two sidewalks; the new bridge has a roadway 36 ft. wide and two 7-ft. sidewalks. The bridge was built under a special act of the Oregon legislature which authorized the city of Portland to issue bonds amounting to $400,000, and the price paid to the contractors was $381,573. The new bridge was designed in all its details by Mr. F. A. Koetitz, vice-president and chief engineer of the Pacific Construction Co., and was erected under the immediate supervision of Mr. F. M. Butler, secretary of that company, and under the direct superintendence of Mr. F. B. Field, general bridge superintendent.

Two 100-Ton Flat Cars have recently been built for the Allis-Chalmers Co. for transporting very heavy pieces of machinery. They are 16-wheel cars, 41 ft. long, and are built low in order to secure the necessary clearance. Evidently the company is not afraid of the "private car line" agitation of the yellow magazines.

The Oregon Short Line Ice Pond, at Humphrey, Idaho.

By H. A. Roberts.

During October and November, 1905, the Oregon Short Line R. R. constructed a dam for impounding water from which to cut ice at Humphrey, Idaho. Humphrey is located near the top of the divide where the railroad crosses the main range of the Rockies between Idaho and Montana. In previous years ice was cut from the Snake River at a point near Market Lake, but owing to the shortness of the season, the harvest was usually many tons below the desired amount. Humphrey was chosen as an ideal spot both as regards natural location for a reservoir site and length of season. The railroad winds up through Beaver Canon, a rocky, narrow gorge, and at Humphrey comes out upon a plateau about one-quarter of a mile wide, keeping close to the foot-hills along the west side. The natural slope of the ground toward the head of the canon is approximately one per cent. A wye is located here on the east side of the main line and two sidings on the west.



Erection of Cylinder for Turntable Pier, Willamette River Bridge.

The site of the dam was chosen along the east side of the main track, extending along the north leg of the wye to the foot-hills. The length of the dam is about 1,800 ft., the highest point above the natural surface of the ground 12 ft., the surface of the impounded water covers about 20 acres. The dam is constructed so that the slope of the bank comes within 2 ft. of the end of the ties. The grade of the roadbed thus forms a buttress for the dam. The back slope is 1½:1, the front slope 2:1, the crown 6 ft. It is built entirely of earth and contains nearly 12,000 cu. yd.

The land upon the site of the reservoir has been used for many years as a wild hay meadow. The top soil varies from a few inches to about three feet. Underlying this is a bed of coarse gravel. Fearing that this gravel might allow the water to leak out, no borrow pits were allowed to be made into it, and whenever gravel was struck, the borrow pit was abandoned. Later development showed this theory to be correct. The sod formed by long use as a hay field was quite thick and tough. It was necessary to use a large amount of this sod or be compelled to make a prohibitively long haul for good earth. The ground on the dam site was ploughed before grading was begun, in order to break up the sod and aid in forming a bond between the natural soil and the embankment. During construction the open ground at times froze 1 to 2 in. during the night so that it was necessary to keep a team ploughing during part of the night in the borrow pits. The days were warm so that by noon the frost was all out of the ground in the pits. Owing to the amount of sod and frozen material put into the dam, it was impossible to keep the "lift," or layers, less than 2 ft., and at times it was much more than this. The work was done by contract, and the contractors had only No. 2 wheelers for this work so that the material received a thorough tamping by the teams. This soil contained a considerable amount of alkali and in places looked almost like a natural cement. It was quite moist, so that there was no need of sprinkling.

Water was turned into the reservoir as soon as the grading was finished. It took 24 days to fill the reservoir to the desired height, 2 ft. below the top of the dam. In spite of the unfavorable conditions under which the dam was built, up to the present time, Jan. 15, no water has come through the embankment. As the reservoir gradually filled, considerable water began to rise below the dam and on the west side of the main line between it and the sidings. This was due to the fact that in several places the gravelly subsoil was exposed at high points and in the beds of old channels. It is expected that the bottom will gradually silt up and stop most of this leakage.

The natural course of the creek which feeds the pond lay in a line parallel to the track and about 150 ft. from it on the site of the reservoir, passing through a bridge under the wye track. A relief gate was built to discharge through this bridge. It was constructed entirely of timber with wing walls 15 ft. long on each side. The latter were constructed by driving sheet-piling close against a stiffening framework. Sheet-piling was also driven along the sills beneath the gate. This driving was done by hand. Thorough tamping with iron tamping bars was done around the gate and wing walls.

A spillway was constructed at the end of the dam next to the foot-hills. This spillway was formed by simply excavating into the solid ground of the hillside and making a channel leading away from it. A timber was sunk for the crest with supporting posts behind it and riprap laid by hand 12 ft. on each side.

All the ice cut is shipped to other stations on the road for storage where it will be needed. At the point where the ice is loaded on the cars the top of the dam is 7 ft. above the top of the rail. An elevator is used for lifting the ice to a height of about 8 ft. above the top of the dam. It is then dropped through a chute into the cars. The elevator was purchased from an eastern firm and is made to be used in an upright position. However, it was found that slush ice and chips accumulated around it so rapidly that it blocked the runway in a very short time. The elevator was then inclined about 45 deg. and in this position carries the slush ice and chips to the top and drops them free of the runway.

The chute curves sharply from the elevator until it lies in a line parallel to the track 5 ft. 6 in. from center of track to side of chute and is long enough to load four cars at one time. Short aprons bridge the opening between the cars and the chute. For diverting the cakes of ice into the cars, a switch made of 3-in. wrought iron pipe is used. This pipe is 6½ ft. long and curved so that the distance from chord to curve is about 12 in. On the down grade end is a piece of pipe of same diameter put on with a union at right angles to main pipe. This fits into a wooden socket loosely enough to allow revolution. When switch is closed the free end of the pipe rests against side of car; when open it rests against a post on the opposite side of the chute from the car. As the elevator can be operated fast enough to lift twelve to sixteen cakes of ice per minute, it takes careful watching and quick action in order to keep the cakes evenly distributed among the four cars.

A second-hand engine and boiler were rescued from the scrap heap at the Pocatello shops, and with slight repairs, put into good condition for use in running the elevator. With about 45 men to operate it, this plant can cut and load between 20 and 30 cars a day, averaging 20 tons to the car and costing about 16 cents per ton. The cost of grading was $2,200; for relief gate, $135 for material and $165 for labor. The elevator cost about $300. Other prices are not yet obtainable.

The quality of the ice, the convenience and cheapness in loading and above all the certainty of the season make this, from the present outlook, a very successful plant. The work was done under the supervision of Division Engineer R. B. Ketchum.

The Automatic Stop Valves used on the Vyrnwy aqueduct of the Liverpool water-works have occasionally been designated as unnecessary precautions against a very remote contingency. Yet it appears from the "Builder" that a break in the aqueduct has happened and one of these valves operated in the manner intended, stopping the flow above the valve and preventing what might have been a serious flood. This apparatus is of the type illustrated in this journal on Jan. 19, 1895. It consists of a main gate closed by a heavy weight in about fifteen minutes, a rate fixed by a sort of dash-pot. The closing takes place most slowly toward the end of the movement, when the danger of water hammer is greatest. The gate mechanism is held in place by a trigger, which is released by the movement of a disk suspended within the main so as to have its position changed by a sudden marked increase in the velocity of flow in the pipe such as would be caused by a break in the aqueduct.

Portion of New Wall and Old Tunnel.

Relative Position of Side Wall and Old Tracks.

THE RECONSTRUCTION OF THE OSSINING TUNNEL, NEW YORK CENTRAL R. R.

The double track of the New York Central & Hudson River Railroad at Ossining, has occupied a narrow space terraced out of the earth and rock between the shore of the Hudson River and the foot of the steep bank. For a distance of about 1,000 ft. opposite the buildings and yard of the Sing Sing State prison the tracks were partly in an open cut with stone retaining walls and partly in two double-track tunnels about 400 ft. and 200 ft. long respectively, with stone side walls about 10 ft. high above base of rail which supported, at the springing line, a segmental brick arch roof of 24 ft. span and about 7 ft. rise with a thickness of 2 ft. at the crown and a total clear height of about 17 ft. above the base of rail.

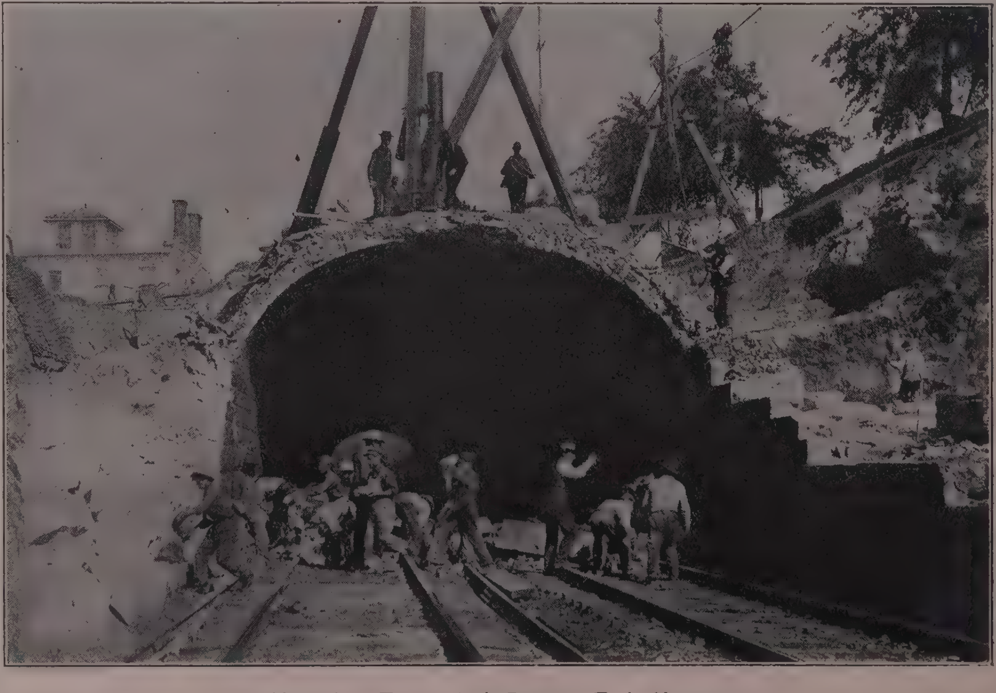
The improvements comprised in the electrification of the metropolitan zone of this railroad system include the change from two tracks to four tracks at this point and it was decided to leave the existing tracks in practically the same position that they now occupy on the river side of the right of way, making a cut on the land or east side of the right of way to receive the two new tracks. It was also decided to reduce the tunnel construction to one section of four-track structure 400 ft. long, besides which there is to be about 1,700 ft. of new concrete facing for the rock cut and retaining wall for the surcharge of earth.

It was required to make these improvements without any interruptions to the very heavy traffic of freight and express trains. The old tunnel and retaining wall construction was all to be removed, a considerable amount of rock excavation which required blasting was to be made close to the old tracks and the new masonry was to be built alongside of, and over them. The old tunnels were probably built in open cut and the back fill over them consisted of earth with a maximum depth of about 6 ft., part of it being sodded and part paved to form a roadway opposite the prison entrance. It was decided to remove the old structures and build the new in open cut. This plan presented serious difficulties on account of the location, the restricted space and the heavy traffic, but has now been carried well towards completion in a successful and satisfactory manner.

The right of way on the west or river side is bounded by a massive stone wall about 14 ft. in height, which surrounds the prison enclosure and serves more as a barrier than as a retaining wall. This wall will remain undisturbed except for such repairs as may prove necessary, and therefore is not an important factor in the reconstruction. The concrete retaining wall on the opposite side of the tracks is from 8 to 30 ft. high with an averaged height of about 20 ft. It is founded throughout on rock generally at or above the track level. The rock is of a micaceous character common in this locality and has irregular stratification, generally dipping approximateyl 45 deg. The surface slopes towards the river and in most places here there is above it from 2 to 10 ft. of clay, sand, gravel and loam covered with grass, trees and bushes.

The rock cut is made with a rough vertical face and the earth above it is excavated with as steep a slope as will stand, usually about 1:1. The surface of the rock cut is protected with a solid concrete facing 30 in. thick at base of rail and battered 1:24. The face concrete is continued above the top of the rock to form an integral part of the retaining wall 33 in. wide under the coping, which is battered and offset on the rear face and is seated on the leveled sound rock as indicated in the typical cross section. A double bank of 32 vitrified electric wire conduits is built in the lower part of the concrete facing or retaining wall. The footing and body of the wall are made with 1:4:7½ and 1:3:6 concrete, respectively, and the coping is made 1:2:4, all of them using Giant Portland cement and 2-in. and ¾-in. broken stone. Weep holes 4 in. in diameter are built in the wall at intervals of about 15 ft. and discharge through its face at rail level. On the back of the wall a gutter is formed in the surface of the rock, which conducts to the weep holes the drainage collected in the mass of loose broken stones piled against the back of the wall and covered by the back fill.

The top of the bank is dressed to a slope of about 1½:1 and finished with a paved gutter 3 ft. wide and 9 in. deep adjacent to the coping of the retaining wall. The wall is provided with transverse vertical expansion joints about 50 ft. apart. It has refuge niches 100 ft. apart and is buttressed on the rear at intervals of 120 to 140 ft. to provide seats for electric transmission poles. There are splicing chambers about 8 ft. high and 3 ft. deep, formed in it with horizontal pieces of old rails, reinforcing the concrete in

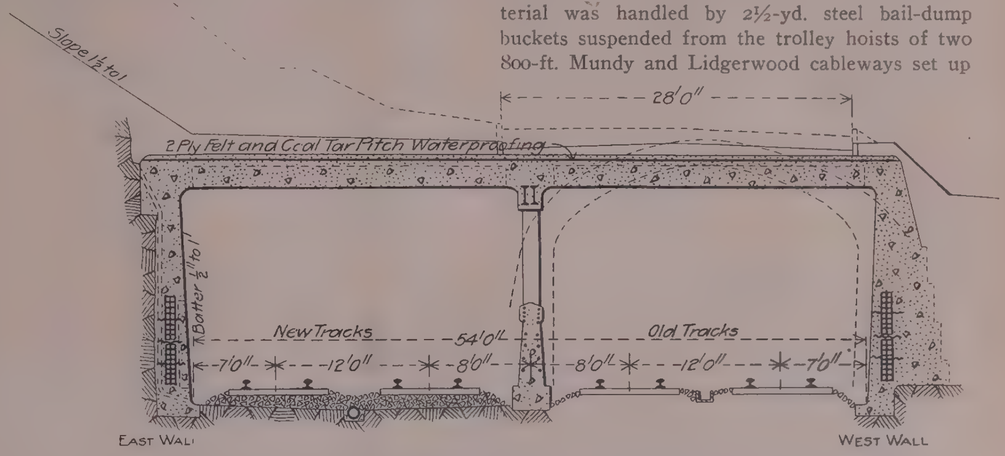


Breaking Down Tunnel Arch Between Train Movements.

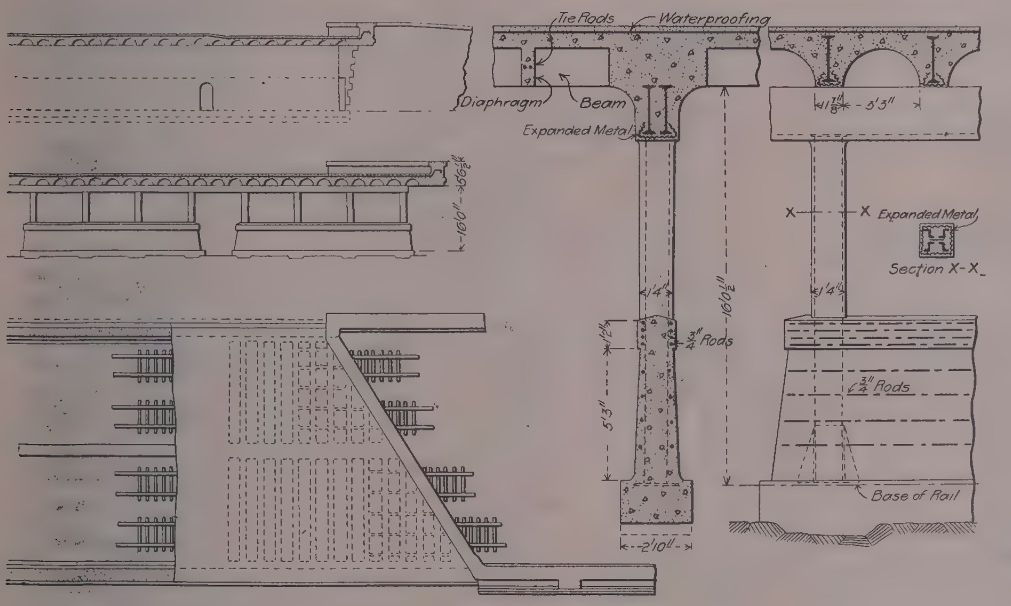
the roof. Part of the wall is on a tangent and part is curved so that with the special features here noted the construction became quite irregular and required great care and accuracy to secure a good appearance.

The excavation was carried about 18 in. below the base of rail and a shallow trench formed in the center to receive a 10-in. drain pipe between the two new tracks. The old and the new retaining walls are about 56½ ft. apart in the clear and the side walls of the tunnel are 54 ft. apart at track level. The tunnel is made as indicated in the typical cross section with concrete side walls and center columns supporting a flat concrete roof. On the river side the side wall is offset on the back and has a maximum thickness of about 6 ft. at the bottom where it includes such a portion of the old tunnel wall as was found to be sound. On the land side the wall is in some places simply a facing for the rock cut and has a maximum thickness of 30 in. In other places the upper part serves also as a retaining wall and is made thicker, corresponding in a general way to the retaining wall of the open cut.

The columns are spaced about 12½ ft. apart on the center longitudinal axis of the tunnel and are arranged in groups of 4 or 5 with their bases united by a solid collision wall of concrete reinforced with horizontal rods to form piers intended to deflect cars and diminish the impact in case of a derailment. The tops of the columns are connected by two longitudinal 24-in. I-beams encased in concrete which support the transverse I-beams 20 in. and 24 in. deep, spaced about 4 in. on centers. Between them are jack arches forming the roof of reinforced concrete, flat on top, with a minimum thickness of 6 in. and stiffened by a series of transverse ribs about 12 in. wide, 20 in. to 24 in. deep over all, and about 4½ ft. apart on centers. The details of the columns and roof and their reinforcement are shown by the accompanying drawings. The roof and walls of the tunnel and the back of the retaining walls in open cut are waterproofed with tar about ¼ in. thick put on in three coats.



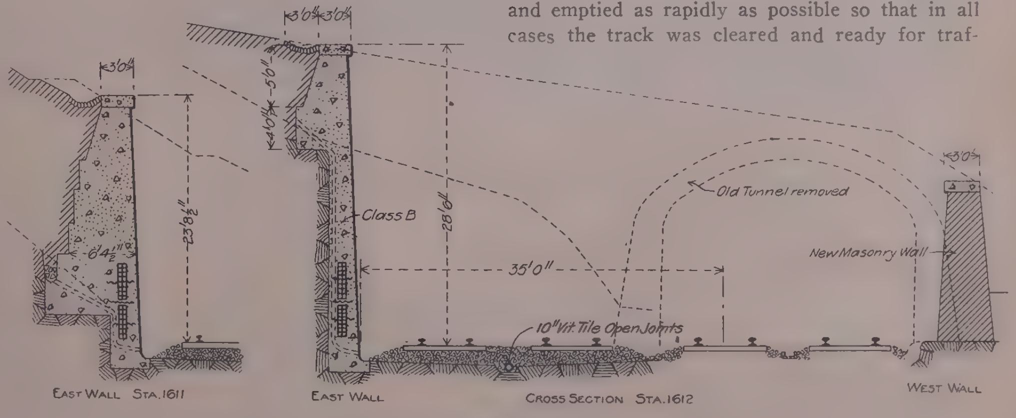
Cross Section of Four-Track Tunnel.



Central Supports of Tunnel Roof.

At one end the tunnel portal is at right angles to the tracks and at the other end it is oblique to them. In both cases it has a vertical wall rising about 2 ft. above the top of the tunnel roof and forming a parapet with panelled exterior surface and a coping continuous with that of the retaining walls of the open cut. A 20-ft. macadam roadway with paved gutters and cut stone curbs extends longitudinally over the full length of the tunnel roof, swinging from one side to the opposite side and making a short radius bend of nearly 90 degrees at the square portal end and a more oblique bend at the other end where it is tangent to the Skew portal.

That portion of the tunnel roof not covered by the roadway is paved with 6 in. of cinder concrete, forming a promenade which is crossed near one end by a transverse sidewalk with a surface of stone screenings which leads to the foot of a flight of concrete stairs supported on the solid earth of the embankment slope. Near each portal of the transverse ribs of the tunnel roof are secured by pairs of horizontal longitudinal tie rods about 3 ft. apart passing through them half way between the top and bottom, and enclosed by protecting diaphragms of solid concrete 6 in. thick.

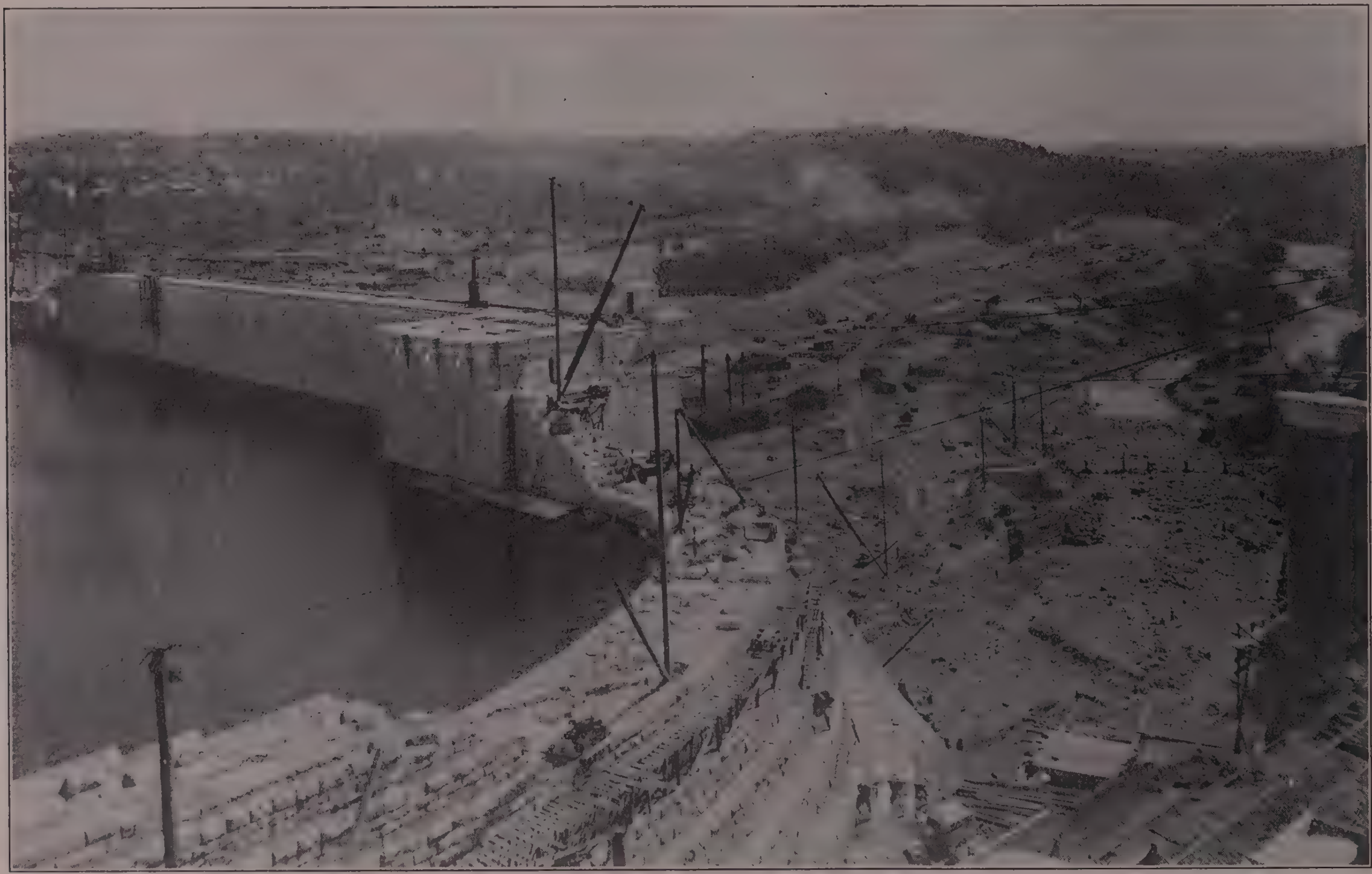


General Design of Retaining Walls of Tunnel Approaches.

Excavation for the two new tracks in open cut was made by ordinary methods of drilling and blasting, care being taken to use light charges of explosives and to avoid obstructing the adjacent tracks with the debris. The excavated material was handled by 2½-yd. steel bail-dump buckets suspended from the trolley hoists of two 800-ft. Mundy and Lidgerwood cableways set up parallel with the tracks approximately on the center line of the excavation. One cableway was located south of the south tunnel and the other north of the north tunnel. The excavation was commenced before removing the old retaining wall and as fast as it was carried approximately to subgrade, a standard gauge track was laid in it close to the wall and connected with the main tracks so that platform cars could be run there to receive the excavated material from the cableway.

The removal of the old tunnel was carried on simultaneously with the excavation of the open cut alongside. The earth was first stripped from the tunnel roof and a stiff-leg derrick with a 40-ft. boom was seated on the brick arch near the end and moved backwards as the work progressed. A transverse row of holes was drilled 15 in. into the brick work about 15 ft. from the end of the arch. Each hole was loaded with ¼ stick of dynamite and during the maximum intervals of 38 minutes between trains the blasts were fired. These threw down the brick work in large masses on the main track and it was loaded by a large gang of laborers into the steel buckets and hoisted by the overhead derrick. The buckets were swung around underneath the cableway and emptied as rapidly as possible so that in all cases the track was cleared and ready for traffic before the next train was due. This method involved rehandling the spoil when it was loaded into buckets and deposited by the cableway on the cars. This extra work was, however, justified by avoiding the delay which would have been occasioned by trying to handle the buckets directly from derrick to cableway. The old tunnel arch could have been thus removed at the rate of about 35 lin. ft. per day, but it was delayed to keep pace with the side excavation, which progressed at the rate of about 50 ft. a week. It was at first proposed to provide a movable steel shield traveling inside the tunnel to protect the tracks during the removal of the tunnel arch, but this was found undesirable and the method above described has proved safe and satisfactory.

The facing for the vertical sides of the rock cut was made by filling concrete into the space front of a mould made with horizontal plain left between the irregular rock surface and the boards nailed to vertical timbers. The latter was braced by inclined struts on the outside and by wires anchored to the rock on the inside. The upper ends of the verticals were also secured by horizontal transverse timbers reaching to the rock or earth slope and serving to support a wheeling platform on which the concrete was delivered. The retaining wall above the surface of the rock was made with complete moulds having front and back faces and transverse bulkheads. All moulds were made in 50-ft. lengths corresponding with the locations of the expansions joints. No attempt was made to build them in movable sections and they were entirely knocked down and rebuilt for each portion of the wall. Usually the mould was stripped from the concrete any time after the latter was 24 hours old. Special care was taken when the concrete was laid to spade it next the face of the mould and insert there cement mortar to give a smooth and uniform surface to the concrete and avoid the formation of laitance which sometimes collects there and causes the separation of the surface when the latter is made with the use of a removable steel plate. After the concrete had set a few days the surface was well rubbed by hand with 2x2x10-in. corrundum bricks to give it an exceedingly smooth, uniform, white texture, which is very attractive.



View of the Croton Dam While in Service before the Completion of the Crest.

At the commencement of operations the contractors installed a power plant at the extremity of a dock about 400 ft. from the south portal of the old tunnel. Here they established a stiff-leg derrick with a 40-ft. boom for unloading and handling materials and installed a McKiernan air compressor to deliver air at about 100 lbs. through two 3-in. mains extending from end to end of the work and provided with outlets about 50 ft. apart to which branches were connected for the 6 Rand drills used for the rock work and for the removal of the old masonry. About 2,000 ft. of 24 in. industrial track supplied by the C. W. Hunt Co. was laid from the wharf to the top of the bank adjacent to the work and about 40 ft. above track level and continued parallel with the track about 50 ft. away from it. A hoisting engine with a ⅝-in. tail line pulled one-yard dump cars loaded with sand, cement and broken stone from the wharf, where they were delivered by schooners, to the top of the bank and thence distributed the stone and sand in piles containing about the quantity estimated for the work.

Two Ransome concrete mixers were installed on the slope just above the top of the retaining wall and were just located at opposite ends of the cut, and as the work advanced were moved along to eventually meet at the center. Materials were delivered to them from above by gravity through wooden chutes. They discharged the concrete directly into barrows which were wheeled on runways above the top of the finished wall and dumped into the moulds as required. The derricks were operated by National double drum hoisting engines with boom-swinging gear and the concrete mixers were operated by individual steam engines furnished with the machines and run by compressed air.

The principal quantities in the execution of this work include about 10,000 yds. of concrete and the excavation of about 30,000 yds. of earth, 15,000 yds. of rock and 5,000 yds. of old brick and stone masonry, besides taking down and rebuilding 2 ft. back of the original position a large part of the old wall on the river side of the track. Work was commenced in August, 1905, and has been prosecuted vigorously with an average force of about 100 men.

The improvements above described have been designed and supervised by the engineering department of the New York Central & Hudson River R. R., Mr. W. J. Wilgus, vice-president. The drawings were approved by Mr. Olaf Hoff, engineer of structures, who has since resigned to enter contracting. It was executed under the direction of Mr. W. H. Knowlton, principal assistant engineer, Mr. C. K. Lawrence, resident engineer in charge. Messrs. Ford & Waldo, New York, were the contractors.

Prussian Highways.

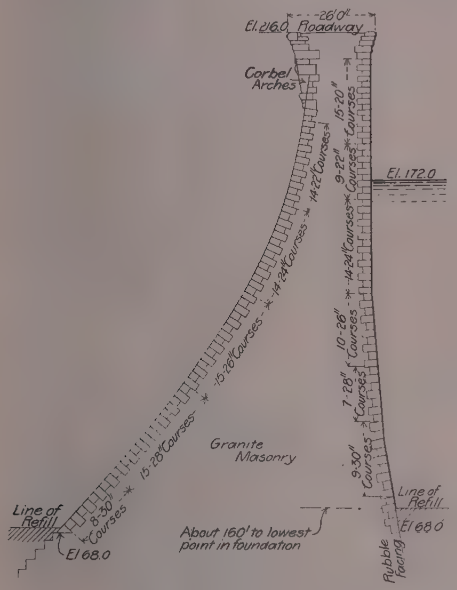
The Prussian highways were turned over by the royal authorities to the provinces, districts and counties in July, 1875. At that time their total length was 59,024 km. According to the "Zentralblatt der Bauverwaltung," their length 25 years later was 96,510 km. In this time the length of road per 100 sq. km. has increased from 16.94 to 27.7 km., and per 10,000 population from 22.93 to 28.03 km. The provincial roads alone have increased from 29,097 to 32,731 km., and in this quarter century about $139,900,000 has been spent on them, or approximately $250 per mile per annum. This does not include the roads under the charge of the district and county boards, but it is not possible to secure any definite data concerning them at present.

A STATUE OF MATHIAS BALDWIN, founder of the Baldwin Locomotive Works, has recently been presented to the city of Philadelphia by the officials of the works, and will be placed in Fairmount Park.

Pointing Ashlar Masonry on the new Croton Dam.

The specifications of the new dam now being completed for New York City across the Croton River, in Westchester Co., N. Y., prohibited the pointing of the work until after the masonry had been made for a considerable time. This prevented the pointing from being systematically done simultaneously with the advance of the masonry. The pointing of the lower portion of the structure was, however, completed at various convenient times so as to enable the filling to be placed against the walls up to the bottom of the reservoir, and to the restored surface of the valley on the down stream of the dam, a height of about 150 ft. below the deepest part of the footings.

The cross section of the dam is about 26 ft. wide over all at the coping and 216 ft. wide at the lowest point. The up stream face is battered very slightly above the bottom of the reservoir and somewhat more below this level. The down stream face is a curved surface with a batter which increases from the vertical at the crest to more than 1 to 1 at the base. The heavy coping projects about 2 ft. on the up stream side and about 8 ft. on the down stream side, where it forms part of an ornamental cornice supported on projecting corbel arches of 16 ft. span, with faces overhanging the vertical plane.

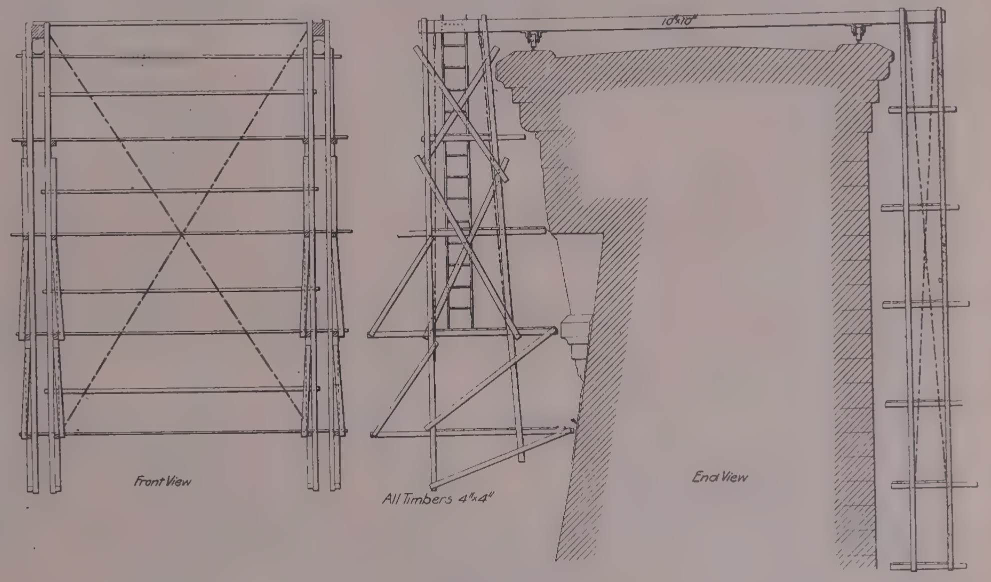


Upper Part of Croton Dam.

With the dam nearing completion strenuous efforts were made to advance the work with the utmost rapidity so that it might be put in service before it was entirely finished in order to store additional water supply for New York City in the fall and winter of 1904. The masonry thus advanced far beyond the pointing, the latter having been carried up only to about elevation 194 on the down stream face and 110 on the up stream face. The crest of the dam is at elevation 216 and as the length over all, including the spillway is about 2,050 ft., there remained a total surface of approximately 400,000 sq. ft. to be pointed. The masonry on both faces of the dam was of large dimension granite ashler with rock face and dressed arrises except in the case of the coping and ornamental courses which are of cut stone. The regular courses average about 24 in. high in the upper part of the dam and many of the headers and stretches have faces 40 in. and 78 in. long, respectively. There was approximately 18,000 lin. ft. of pointing to be done on the up stream side.

Up to elevation 150, about 60 ft. above the level of the finished grade, the curve of the down stream face of the dam slopes at an angle of about 45 deg. with the vertical and it was possible to walk along on the horizontal upper sides of the offset courses without the use of scaffold or other protection. Above this level the inclination became steeper and some sort of working platform was necessary, and being provided, was also utilized to facilitate the handling of materials and tools for the pointing down to about elevation 130. Each platform consisted of a swinging scaffold of about 2½ ft. wide and 14 ft. long enclosed by a substantial hand rail around both ends and one side. It was suspended like a painter's scaffold with two Manila rope four-part tackles attached to steel bales on the scaffold and steel hooks engage the finished coping. Four of these were provided and were easily moved by the two men that ordinarily worked on each. These two men average about 250 lin. ft. of pointing in 8 hours, and ordinarily did the work in successive vertical strips about 14 ft. long and from 20 to 40 ft. in height.

Near the top of the dam the height above the ground was so great that there was danger of dizziness for men working on the swinging scaffolds. The overhanging of the cornice on the down stream face was also an obstacle for the use of such scaffolds, therefore a special rigidly framed traveling scaffold was used for the pointing on both faces of the dam above elevation 194. This traveler was about 20x36 ft. in plan and was constructed on the saddlebag principle. The horizontal framework had two transverse beams supported by double-flange wheels on rails laid on the up stream and down stream copings. These timbers projected 6 and 8 ft. beyond the rails, thus forming double cantilevers from which were suspended the scaffolds by means of two vertical or slightly inclined timbers at each end of each transverse beam. These vertical pieces were X-braced, transversely by struts and longitudinally by screw rods, thus forming rigid suspended towers in which working platforms were accessible by fixed ladders. The platforms were enclosed with protecting hand rails, and were made with cantilever projections extending them under the overhang, close to the face of the battered masonry. Ordinarily about 6 men were employed on the traveler at once, being distributed on both sides of the dam and on the different platforms as required. The traveler was easily pushed along by two or three men as the pointing advanced and each man on it averaged about 250 lin. ft. of pointing daily.

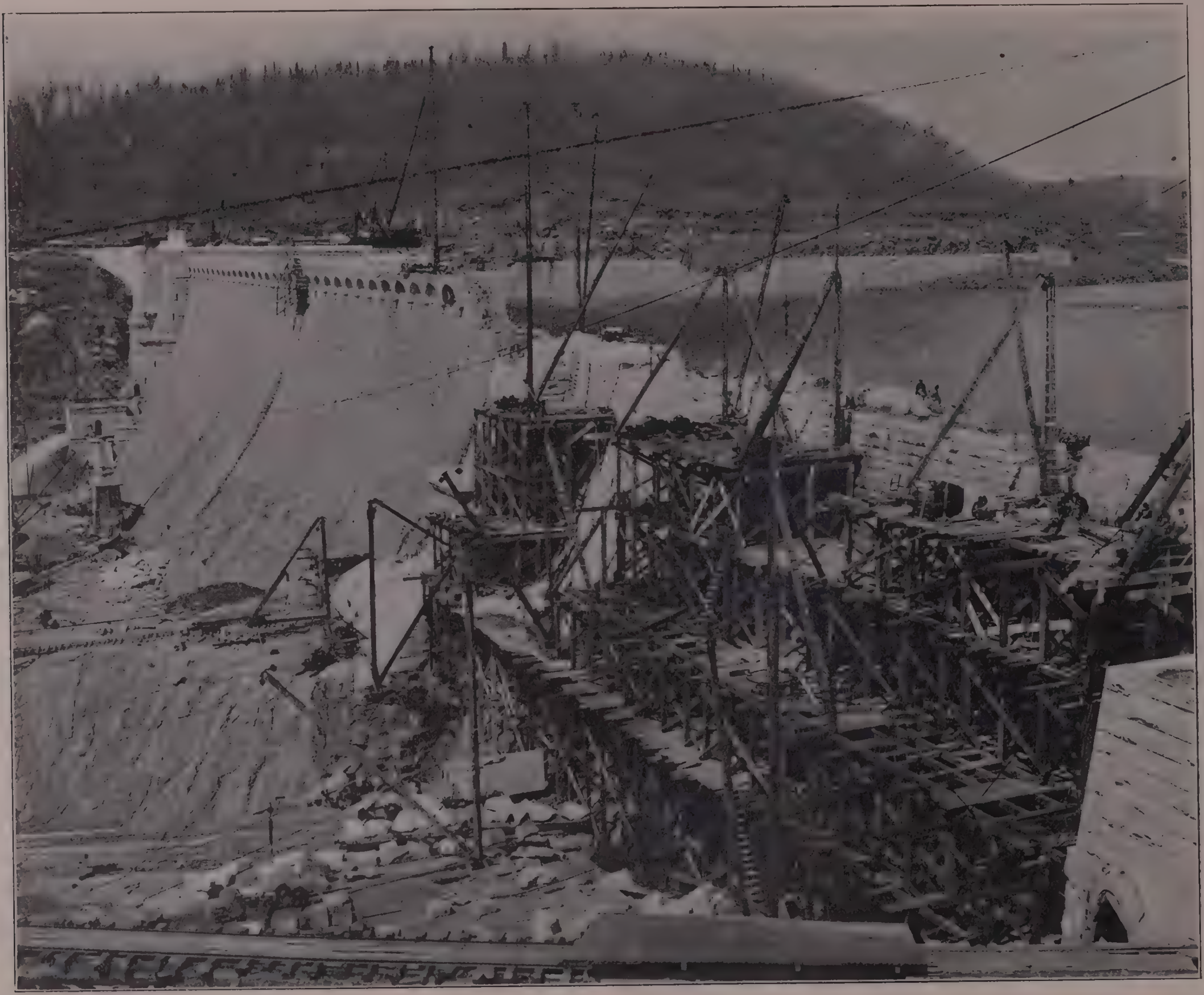


Pointing Scaffold.

On the nearly vertical up stream face of the dam pointing was only completed to about elevation 110 when the water was impounded in the fall of 1904 and rose to elevation 172, about 125 ft. above the bottom of the reservoir. When this water was drawn off for city service and subsequently when the remainder below conduit level was wasted, advantage of its presence was taken to provide a floating scaffold from which the pointing was very advantageously done as the water level was lowered. When the water was being wasted the rate of discharge was regulated to correspond with the progress of the pointing so that the floating scaffold kept exact pace with the workmen and they were always maintained in the most convenient position. The 7½x32 ft. floating platform had a framework of 4x4 in. longitudinal timbers bolted together with pairs of 2x4 in. transverse planks with 12-in. spaces between them, thus making a skeleton platform with spaces in which were wired securely 10 empty oil barrels tightly sealed. These gave sufficient buoyancy to float the raft and its burden with the floor about 6 in. above water. The oil barrels were not in any way injured and the timber did not require framing or cutting. On this platform the men worked very comfortably and pointed an average of 250 lin. ft. per day each.

The joints had an average thickness of ½ in. vertical and ½ in. horizontal, and were first raked out thoroughly to a depth of 2 in., an operation which was rather slow and difficult on account of the great hardness attained by the mortar which was made 1 to 2 with Giant Portland cement. The pointing was done with 1 to 1 Giant Portland cement mortar driven in hard and finished concave with a rounded tool. The mortar was used quite dry and was mixed by hand on the floats as required. For the cut stone work the joints were not more than ⅜ in. thick and were not raked out more than 2 in. deep.

The accompanying illustrations of the traveling and floating scaffolds are necessarily of too small scale to indicate more than their relative position and general appearance, but they are extremely interesting in that they show very clearly the magnitude and character of the great dam and recent features of its construction and appearance that have not previously been published in the series of articles in these pages, which have illustratd most of the principal features of the work. The view dated April 3 shows in the foreground the important system of false work built on the lower face of the dam for the transfer of materials and to support the derricks in building the upper part of the masonry as described in the Engineering Record of July 9, 1904. This false work was built in successive stories as indicated by the offsets, and the derricks were moved up from story to story as was required by the progress of the masonry. The water impounded at this time had a maximum depth of about 120 ft. and a volume of about 13,000,000 gal. or a litle over one-third of the ultimate capacity of the reservoir. At the time the picture was taken the water was being discharged through three 48-in. blow-off pipes in gate house No. 2 at the rate of 1,000,000 gal. in 24 hours, an amount which caused the water level to be lowered from ½ ft. to 4 ft. daily. This rate was regulated to suit the progress made by the pointing crews and had nothing to do with the execution of the work above described. The same picture shows in the background, extending towards the right the 1,000-ft. spillway wall nearly completed except for a short distance in the center. It shows the saddlebag traveler working near the center of the main dam and shows the derricsk completing the coping and roadway toward the south end of the dam.



View of Downstream Face of Croton Dam Showing Pointing Scaffold Hung from Finished Coping.

The other view taken from up stream shows the dam at a time when it was impounding the maximum amount of water and clearly indicates the relative position of the curved spillway and the straight main dam with gate house No. 2 between them. The saddlebag traveler is seen toward the farther end of the dam and two floating scaffolds are moored against the face of the masonry at the gate house. On one of them trestles about 10 ft. high are placed to enable the pointing to be extended to a height of 15 ft. above the surface of the water. This picture gives at the right a specially comprehensive view of the valley below the dam before the improvements were made there which were described in our issue of Jan. 6. There can be distinctly seen here the power house and other buildings, roads, material tracks, and derricks belonging to the contractor's plant which have since been removed, as well as the untrimmed spoil banks that are now carefully graded and sodded. At the right is seen the dry bed of the Croton River, which in times of freshet has been filled to a depth of several feet with a rapid flowing stream. A new highway bridge required by the construction of the dam is shown at the extreme right in the background, and in the foreground there is a trestle bridge across the channel adjacent to the abutment and wing walls of the long plate girder arch span which has since been erected and which was described in our former article.

It will be remembered that the dam has been constructed under the direction of Mr. W. H. Sears, Chief Engineer, and his predecessors, by Messrs. Coleman, Breuchad & Coleman, Contractors. Mr. Jules Preuchand has been in direct charge of the work and Mr. J. B. Goldsborough, Superintendent.

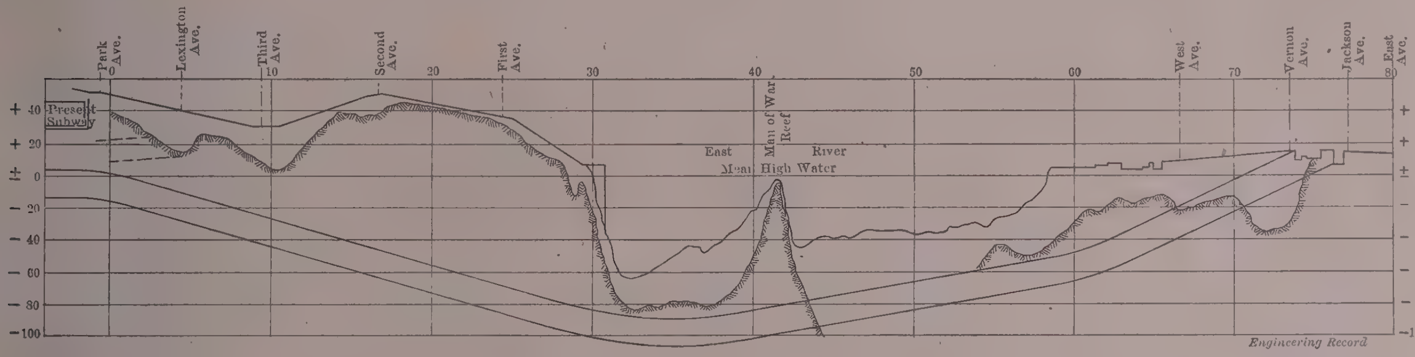
A New Gas Calorimeter.

A new gas calorimeter has been designed by Prof. C. V. Boys, one of the Metropolitan Gas referees entrusted with the enforcement of new regulations governing the quality of gas furnished by the London companies. The instrument is intended to give more accurate results than older forms without being any more complicated in operation and was described by him in a paper read a couple of months ago before the Royal Society. The necessity for some such instrument is generally recognized. The constant development of the gas industry in the face of severe competition from electric lighting companies is due in a considerable degree to the attention now given to the calorific power of gas as distinct from its illuminating power. The rapid improvement of incandescent mantles, particularly those of the inverted type, and the availability of economical and very convenient stoves and heaters have raised the calorific power of gas to a position of prime importance.

The Use of Gasolene Motor Cars is being extended by the Union Pacific R. R., five having been completed, and four are under construction.

THE NEW YORK & LONG ISLAND RAILROAD TUNNEL.

Closely related to the New York Rapid Transit Railway system, the improvements of the New York terminus of the New York Central & Hudson River R. R., and the connection of the Pennsylvania R. R. and Long Island R. R.'s by tunnels under the East and North Rivers, is the plan for connecting Long Island City with New York by a double-track tunnel under the East River in the line of 42d St., New York, which is intended to bring electric cars from the Borough of Queens to a point under the Grand Central Depot and the Rapid Transit Subway station, where passengers can be transferred to either transportation system. There will be two parallel single-track tunnels 28 ft. apart on centers and about 17,000 ft. in total length which will pass under the center of 42d St., New York, and across the East River to a point about 2,000 ft. beyond the shore line, where the tracks will emerge through open cut and will have connections with existing surface lines. The tunnel is generally known as the Belmont tunnel and is being built under the provisions of the Steinway charter.



General Profile of New York & Long Island Railroad Tunnel Under the East River.

Operations were commenced early in 1904 when a hasty preliminary survey was made in about two weeks to determine the approximate alignment and to fix the location of the test borings. While these were in progress the final survey was made with great care. A base line about 3,000 ft. long was carefully measured on the 42d St. sidewalk from Park Ave. to the East River. For this work a 50-ft. Brandes steel tape was used with spring balance and leveling attachments. From this line the corners of buildings at street intersections were triangulated, giving the widths of the street at different points.

From these data an average center line was platted on the map and was located in the street by offsets from the base line. Five permanent monuments were set on the center line including one point cut in the portal arch of the 42d St. tunnel, between First and Second Aves.; other points were fixed in Long Island City by concrete slabs and by marks made in the upper parts of buildings. Many intermediate points on the center line were determined by marks at the street level, resource always being had to the principal monuments for checking.

The line was carried across the East River by sights repeated at least 200 times and extending over a period of two months. The length of the line between stations on opposite sides of the river was determined by a triangulation using the base previously measured for the surveys of the Pennsylvania R. R. tunnels at 34th St. This gave a length of about 3,173 ft. and was checked by an independent triangulation using as a base the distance determined by the department of bridges between center points of piers III and IV, of the Blackwell's Island Bridge, about one-half mile farther up the river. The survey and all preliminary work was under the direction of Mr. Allan Appleton Robbins, resident engineer.

Observations on the maximum current in the river were taken with a simple apparatus which consisted essentially of a 200-yard spool of cotton thread mounted on an oiled steel spindle and weighted to sink just below the surface. It was secured, kite fashion, by four diagonal strings, and the end of the thread being fastened, the spool was released and floated down stream. The time was recorded which was required for the thread to be unwound and indicated a velocity of about five miles an hour.

Another rough and ready method to determine current velocity was resorted to by establishing on the scow used for the diamond drill boring work, two ranges about 70 ft. apart parallel with the axis of the tunnel. An observer with a stop watch was stationed at each range and both recorded the time of various floating objects which passed them. Both of these series of observations checked approximately with the results of the Dock Department, which were taken with elaborate apparatus. It is believed, however, that under extreme conditions of wind and moon the current will reach a maximum considerably more than 5 miles per hour.

The surface of the underlying rock was found to be probably at a depth of 3 to 29 ft. below the surface of the ground, in New York and from 3 to 50 ft. on Long Island. Wash borings to approximately locate the rock were made on both sides of the river by Mr. F. W. Miller, New York. Holes were sunk in the usual manner 50 to 100 ft. apart on the opposite sides of the street following the center line.

Ten diamond drill borings were made on the center of the tunnels between the bulkhead lines and as water of a maximum depth of 65 ft. with a 6-ft. tide and a strong current was encountered, the problem of making the drill holes was a difficult one. In previous borings in the East River the drilling machine had been established on pile piers temporarily constructed in the channel, which suffered frequent injury by collision with boats and tows. At this point the water was deeper than at the Battery tunnel and a new method of operations was devised.

The United Engineering & Construction Co., Mr. D. L. Hough, president, who was the contractor for this work, secured the steel traveler tower, 20 ft. square at the base and 68 ft. high, which had been used for the erection of the 72nd St. Armory. This tower had four vertical and one battered faces and weighed about 5 tons. It was lifted by tackles suspended from the leads of an ordinary pile driver mounted on a scow and was towed with it to approximate position where the scow was secured by four anchors. A snatch block was attached to each corner of the base of the steel tower and through it a manilla hawser was reeved, one end of it leading to a very heavy anchor about 400 ft. distant on the diagonal passing through the tower base. The other end of each cable was led to the top of the tower and secured there. The tower was lowered by its tackles until its foot rested in the mud on the bottom of the river, the working platform being then just above the surface of the water. The anchor lines were adjusted by hand tackles on the platform and were made fast so as to guide the tower securely top and bottom.

Difficulty was experienced in setting the tower in position and in three cases it was overturned by the fierce current before it was possible to secure it with guys. No serious damage was occasioned by these accidents and the tower was eventually secured so firmly so as to provide a safe and rigid platform on which the ordinary diamond drilling apparatus was installed by the use of a small breast derrick. The pile driver scow, fitted with a deck house, was anchored adjacent to the tower in its different positions and afforded quarters for the men, supplied steam from its boilers for the drill engine and operated the hoisting tackle as required. The ten top holes have a combined length of about 950 ft. and furnish a core 1⅛-in. in diameter. They were all drilled in about two months at a rate varying from 10 to 50 ft. in 24 hours actual drilling. The time required for moving the tower from one test hole to the next varied from one to five days.

The land portions of the tunnel have a horseshoe shape cross section with heavy concrete walls 18 ft. high and 17 ft. wide over all as indicated in the accompanying detail. This construction requires approximately 9 yds. of excavation and 3¼ yds. of concrete per lin. ft. and most of it will be driven, it is expected, without the use of air locks. Under the river and for some distance on both sides of it the tunnels will have segmental cast iron lining 16 ft. 10 in. in diameter, which will weigh about 4,500 lbs. per lin. ft. of single tube. These sections of the tunnel will be driven with shields and the work will be done under air pressure which may amount to a maximum of between 40 and 50 lb. although it is expected not to reach this amount. The maximum depth of the base of rail of the tunnel track is 102 ft. below mean high tide and the maximum grade of the tunnel is 4.5 per 100. The tunnel has in all places a thick roof of earth, rock, or sand and gravel.

It is planned to construct the tunnel simultaneously from the bottoms of four intermediate shafts. As there are two parallel tubes and work will be carried on in both directions from each of them, this will result in 16 simultaneous headings, of which ten are now being driven. The four shafts were designed to be substantially alike, each having a width of about 18 ft. and a length of 35 ft. parallel with the axis of the tunnel. Shaft No. 1, located on the south side of Forty-second St., near Third Ave., and Shaft No. 2, on the north side of 42d St., at the East River, are each of them offset about 40 ft. from the center line of the two tunnels. Shaft No. 3, near the middle of the river, and Shaft No. 4 in Long Island City, are both centered on the axis of the tunnel. Shafts 1, 2 and 4 are each provided with two 6x8-ft. elevator cages, operated by Lidgerwood hoisting engines. The space adjacent to the elevator frame is used for chuting down concrete materials and for lowering other supplies. The upper parts of the shafts sheeted to retain the earth down to the surface of the rock below which they are not lined.

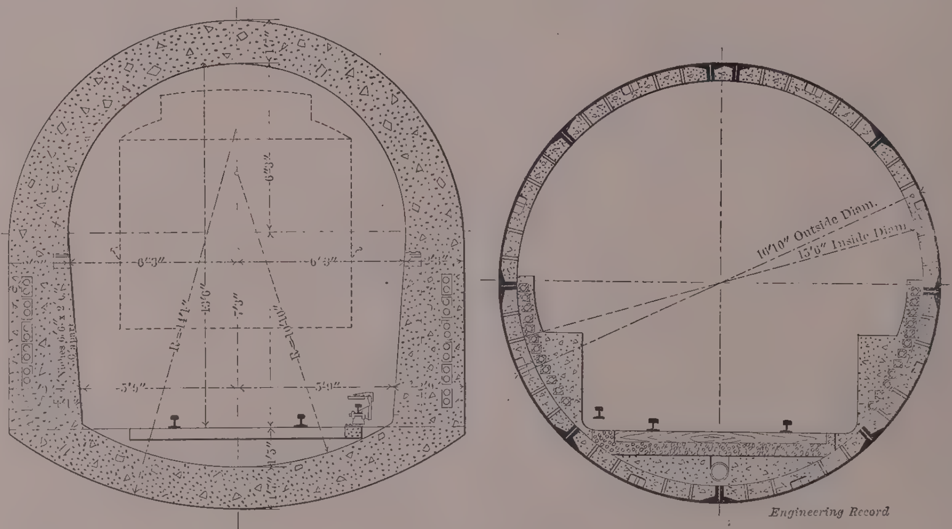
The sinking of Shaft No. 4 was commenced July 14, 1904 and from that time onward the excvation of shafts and tunnels has been vigorously maintained simultaneously with the installation of the plant, no time being lost in preparatory equipment. Shaft 4 was sunk 30 ft. to rock and nearly 30 ft. farther to sub-grade and the two headings started east from it, emerged from the rock at distances of 40 ft. and 80 ft. for the north and south sides respectively. Excavating in them has been stopped pending the purchase of the property above on account of possibilities of settlement. Work on the west headings from this shaft is now progressing and on January 26 had reached distances of 335 ft. and 369 ft. for the north and south headings, the benches being respectively 313 ft. and 307 ft. from the center of the shaft. The site occupied by Shaft 4 and its yard covers 65,000 sq. ft. and was previously occupied by several varnish plants which were purchased by the tunnel company. The one and two-story brick buildings have been retained and are found useful for storage, offices and other purposes. The power plant here installed includes four Heine separate 250-h.-p. boilers, two Ideal engines operating two Fort Wayne engine type generators direct connected to them, and one 1,000-h.-p. Cochrane feed water heater and purifier, manufactured by the Harrison Safety Boiler Works.

Shaft No. 1 occupies a 41x98-ft. site previously occupied by a four-story brick hotel, the demolition of which was commenced August 22. The shaft is sunk through about 22 ft. of earth and 50 ft. of rock and from it the north and south headings on the east side had been driven January 26, to distances of 108 and 141 ft. and the north and south headings on the west side to distances of 107 and 148 ft., the benches in all cases being from 20 to 30 ft. behind the headings.

Shaft No. 2 is located in the yards previously occupied by the O'Rourke Engineering Contracting Company at 42nd St. and East River, where there is ample space for a power plant which is now being installed there and will contain four 250-h.-p. units of Sterling boilers, two 16-in. oil separators with 36-in. x 8-ft. tanks and two Wheeler surface condensers mounted on combined air and circulating pumps. There will also be an electric plant and Ingersoll-Rand air compressors contained in a new brick and iron building now being constructed to receive them. This plant will then suppy compressed air and electricity for Shafts 1 and 2 on Manhattan Island.

Shaft 2 was sunk to a depth of about 112 ft., nearly all of which is through solid rock of nearly vertical strata. From the foot of it a transverse tunnel was driven to intersect the main tunnel and work on the latter has been carried forward in four headings which on January 26 were advanced 81 ft., 85 ft., 64 ft. and 50 ft. for the northeast, northwest, southeast and southwest headings respectively, the benches in these cases being maintained from 20 to 30 ft. behind the headings. The timbering at the top of the shaft is extended above the surface of the ground so as to permit the cages to be hoisted to the top of a double track framed trestle about 15 ft. in maximum height and about 100 ft. long.

This trestle is graded down away from the shaft enough so that the cars of muck descend by gravity and are dumped through the trestle to the ground below or to chutes from which wagons are loaded. Suitable rock is dumped near the crusher plant where it is fed by hand into the depressed hopper of a number 3 gyratory rock crusher which forms part of the plant manufactured and installed by the Power & Mining Machinery Company. This plant has a capacity of 150 yds. of 2-in. stone in 24 hours. From the crusher the stone is automatically elevated by a buck conveyor to the top of an enclosed wooden tower about 50 ft. in height. Here it is delivered to an inclined cylindrical screen which separates 2-in. stone from the dust and the larger pieces. The latter are returned automatically through a chute to the crusher and recrushed. The accepted stone is stored in an elevated bin of 200 yds. capacity from which it can be loaded through chutes to wagons in the yard. The stone dust is saved in another bin where it is stored until required for grout or mortar. A similar stone crushing plant is installed on the Long Island shore at Shaft 4, where a large amount of stone has been stored in heaps on the ground after filling the bins.



Typical Cross Sections, New York & Long Island Railroad Tunnel.

Muck from Shaft No. 2 that is not suitable for concrete stone is delivered at the surface of the ground and the cars are drawn on narrow gauge tracks by mules to the waters edge, where a cantilever platform overhangs the river and permits the cars to be dumped over its edge directly into the dump scows in which it is removed for disposal. At Shaft No. 1 the head work is similar to that above described and the cages are lifted above the street level. The cars are dumped from a platform at the head of the shaft and the muck is chuted directly from this platform over the sidewalk to wagons constantly in attendance on the street. Until the power plant at Shaft No. 2 is in operation, Shafts 1 and 2 and the tunnels at their foot will be supplied by compressed air from the power plant at East 42nd St., operated by the O'Rourke Engineering Construction Company for the work at the 42nd St. terminal of the New York Central and Hudson River Railroad.

Shaft No. 3 is located on a rock reef near the center of the river and a few hundred feet south of Blackwell's Island. Only a small portion of the rock projected above high tide and operations were commenced there July 20, by floating to position and sinking on it eight timber cribs. These were built at Newtown Creek and were towed to position and sunk with rock filling so as to form a cofferdam enclosing the site of the shaft about 87 ft. wide and 165 ft. long. The surface of the rock being irregular, the lower courses of timber in the crib were prepared to fit it by bolting to them additional pieces, sometimes as much as 5 or 6 ft. thick, to correspond with the depressions in the rock. The inner faces of the cribs were sheeted with vertical tongue and groove planks 4 in. thick which were backed up with clay on the outside, forming a puddle to exclude the water. They were set between double rows of ranges and were driven down as the rock inside was excavated, the intention being to carry them down to sound rock and seal them there so as to permit the shaft to be completed in open excavation.

For some time this work was successfully carried on by the aid of two 6-in. centrifugal pumps to keep the water down, but at a depth of 20 ft. seamy rock was encountered through which such great quantities of water rose in the bottom of the excavation that it was impracticable to continue this method farther. It was then determined to modify the original design and sink two separate shafts by the pneumatic process. The first one was started December 15 with a steel shell 11 ft. in diameter and 22 ft. high, made in three sections. The upper section is bolted on and has connected to it an O'Rourke material lock with horizontal top and bottom doors operated by outside balanced levers and having stuffing boxes for the passage of the hoisting rope for the excavating bucket.

The shell is set in a braced framework provided with vertical timber guides and is weighted by 50 tons of car wheels attached with long turnbuckles to eight vertical steel cables suspended from a collar made with several turns of wire cable wound around the air lock. These are adjusted so as to maintain the weights just above the surface of the rock and to lift them, as the case descends and thus keep them in practically the same position as the shaft descends. Four men work in the bottom of the caisson operating two air drills, the exhaust from which has so far been nearly sufficient to maintain the required air pressure. A fifth man on a platform operates the valves and signals.

All the men are hoisted in and out of the lock in a one-half yard cylindrical steel excavating bucket, which is handled by an ordinary boom derrick and delivers the spoil to a dump scow moored alongside the cofferdam. Another derrick is seated on the cofferdam to handle supplies, and will be used later on for the second shaft which will be similar to the one described. The tops of the cofferdam cribs are decked over in places and provide a platform on which is located quarters for the men, office, repair shops, storerooms and a power plant. In the latter are installed boilers, Ingersoll-Rand air compressors and the electric light plant, air receivers, feedwater heater, pumps and other auxiliaries.

Soon after the air pressure was applied to the shaft a fire occurred in the compressed air receiver and the smoke was discharged from it to the caisson. This raised the temperature so much that the men at once closed the valves in order to be able to continue their work. When they opened the valve the smoke and fumes of burning rubber from the hose connection were so poisonous that the men were overcome and four of the six laborers in the caisson were either suffocated or drowned in the rising water which entered the caisson after the air lock was opened and before they could be rescued. This is the only fatal accident which has yet occurred on this work.

Laying Lock Bar Jointed Pipe in Wilmington, Del.

All of the tunnels are being driven with upper headings and single benches, both of them being carried forward full width. Seven or eight Ingersoll or Rand rock drills are operated in the heading and on the bench of each tunnel and a progress of about 6 ft. a day has been made in each with the incomplete facilities heretofore in operation. This progress will probably be increased when all of the new plant is in operation. In one of the headings a special Ingersoll-Sergeant column drill has been installed. It is mounted on a vertical segment which is revolved on its horizontal axis by a worm gear. This enables the drill to move back and forth through a vertical arc so that it cuts a segmental slot of a maximum depth of 6 ft. in the vertical plane in the center line of the tunnel and enables the first section of rock to be much more easily and advantageously displaced than can be done with the use of inclined cylindrical holes only.

Short vertical holes are drilled in the sides of the tunnel at about the springing line and in them are set 5-in. pipes which telescope with 6-in. pipes reaching nearly across the tunnel, forming beams on which a wheeling platform is laid to enable the muck to be delivered from the heading over the face of the bench and dumped directly into the mining cars on the 24-in. surface track, where they are also loaded with muck from the bench. These cars are hauled by mules to the foot of the shaft and then hoisted for disposal as previously described. All concrete materials will be delivered through chutes to the bottoms of the shafts, where the concrete will be mixed in Ransome machines.

Besides the plant already mentioned there will be installed in the different shafts and in the tunnels one Buffalo duplex surface pump, six wooden 1-yd. end dump cars, six all-around 1-yd. steel dump cars furnished by the Arthur Koppel Company and the usual complement of ordinary tools and apparatus. The cast iron segments will be furnished by Davis & Thomas, Catasaqua, and four steel shields 11 ft. long are being made by the Logan Iron Works, New York. They will be equipped with hydraulic machinery made by the Watson-Stillman Company, New York. Phoenix Portland Cement will be used in all construction. Laughlin & Rand furnish the 40, 50 and 60 per cent. Forcite used for blasting. Oil is furnished by the Borne, Scrymser Company and tool steel is furnished by the Crucible Company of America. The Standard Vitrified Conduit Company are furnishing the necessary conduit in one-way 18-in. lengths, 2-way or 3-way ducts 24 in. long. The tunnel has been designed and its construction is conducted under the direction of the New York and Long Island Railroad Company, Mr. St. John Clarke, chief engineer, and Mr. Allan Appleton Robbins, principal assistant engineer. The work is being executed by the Degnon Contracting Company, Mr. Robert Shailer, engineer in charge.

Portland Cement is now extensively used in Pennsylvania collieries, according to Mr. Edward McGrew, as a lining for pipes and pump chambers which contain the sulphur-impregnated waters from such mines. Wood lining is sometimes used in the pumps when they are of the plunger type. It has become customary now, he states, to use bore holes to pump through. A hole is drilled and an ordinary wrought iron casing put in and surrounded with cement grout. After the casing is eaten out by the action of the water, the cement lining protects the hole indefinitely.

Laying a 43-in. Water Main.

The water department in the city of Wilmington, Del., is improving the service by the construction of 10,500 ft. of 48-in. steel distributing main and a 43-in. forcing main 8,700 ft. long from the pumping station to the new reservoir. All of the pipe is made in 30-ft. lengths with lock bar longitudinal joints and riveted butt strap transverse joints and is 7/16-in. and ⅜-in. in thickness according to the pressures. The pipe is shipped from the shops of the East Jersey Pipe Co., Paterson, N. J., on flat cars and in Wilmington is rolled from them to trucks built up to the level of the car floor. It is then drawn by teams to the line of the trench where it is rolled from the trucks to the ground and distributed as required on the side of the road.

The trench is excavated and the bottom shaped to receive the pipe and give it a solid uniform bearing. Wooden beams are placed transversely across the trench and serve as skids on which the pipe is rolled over the trench. A chain sling is put around the pipe a few feet from each end and by them the pipe is hoisted a few inches with Weston differential blocks suspended by the usual manner from shear legs. The skid timbers being released and removed the pipe is lowered to the bottom of the trench, the end connected with the last section laid, the joint riveted, another section laid and so on. One gang of six men handle and assemble in the trench four or five 30 ft. lengths daily, and the corresponding riveting and caulking is done by two other gangs following them.

All of the field riveting is done by hand, and the pipe, although tested at the works, is again tested by hydraulic pressure after the transverse joints are riveted. The work is being executed under the direction of Mr. Theodore A. Leisen, chief engineer of the water department.

Condensing Water Litigation.

Litigation over condensing water between two Massachusetts mills shows the danger of being too generous in giving away rights to water. The suit where this matter came up was brought by the New England Cotton Yarn Co. against the Laurel Lake Mills, and has just been decided by the Massachusetts Supreme Court, 76 N. E. Rep. 231. The defendant and plaintiff were respectively upper and lower riparian owners on the same stream. The plaintiff's predecessor constructed a pond below its mill, into which it discharged water drawn from the stream for condensing purposes. The defendant also drew water for condensing from the same stream, but instead of discharging it directly back into the brook piped it into the pond. The plaintiff's predecessor and the defendant made an agreement, binding on their successors and assigns, permitting this practice in consideration of an annual payment by the defendant. The plaintiff has now found this use of the water to be irksome and brought the suit to secure the full natural flow of the stream to which it is entitled as a riparian owner. The court rules, however, that the defendant had the right to discharge all its condensing water, without restriction as to the source from which it was derived, into the plaintiff's pond, although it was thus made unavailable for the latter's use, notwithstanding a clause of the contract providing that "neither party waives any rights as riparian owners."

Tests of Boiler Furnaces at the Ohio State University show that the brick setting continues to absorb heat continuously up to 72 hours after starting the fire, and that the average waste of heat in brick furnaces is 8½ per cent.

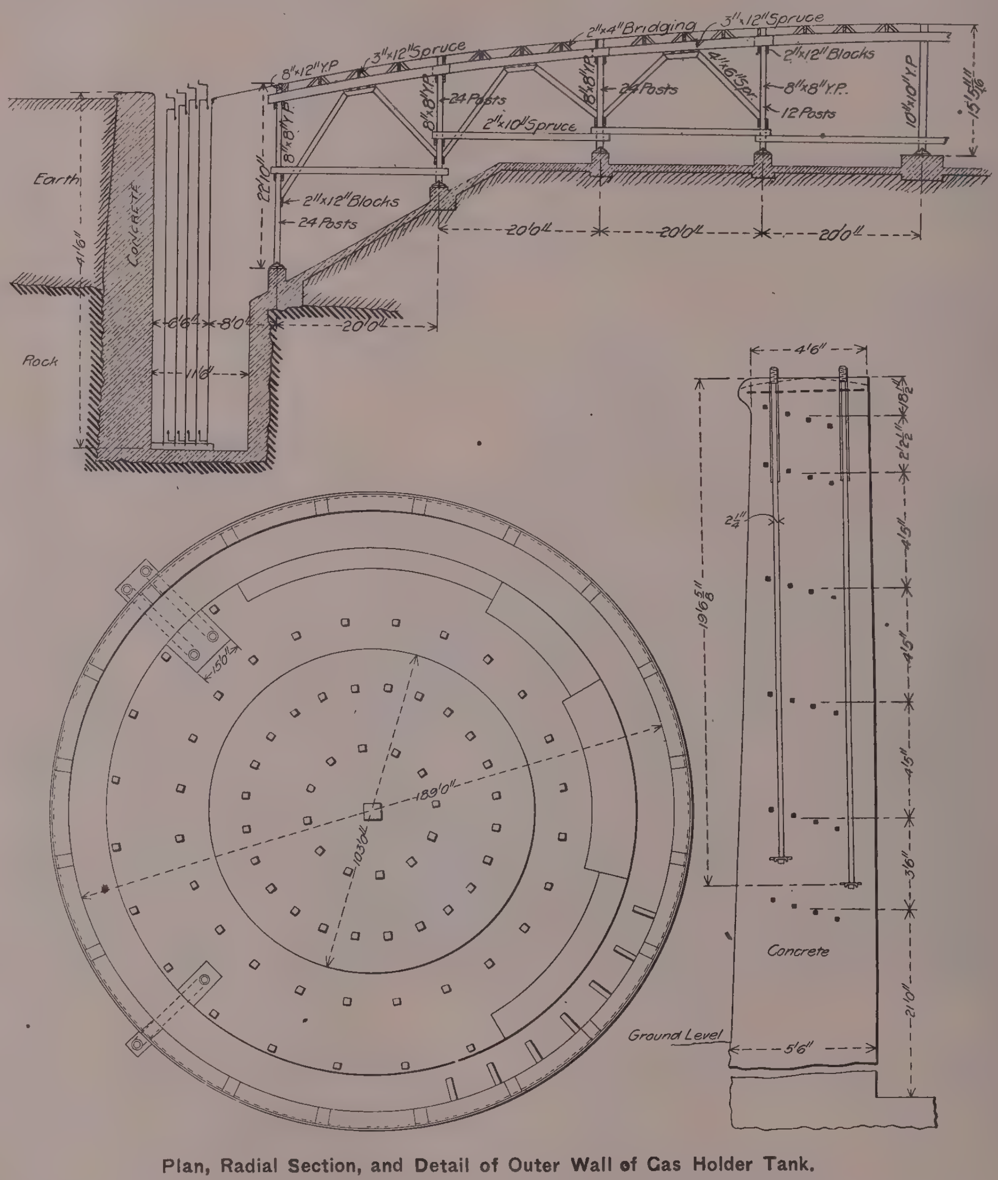
A Large Concrete Gas Holder Tank.

A sunken concrete tank for a 5,000,000 cu. ft. gas holder of the Central Union Gas Company, has just been completed at the foot of 136th St. near Locust Ave., New York City. It is a large monolithic structure built under some difficulties and involved the use of methods and plant on a large scale which had not previously been used in this country. The tank has an extreme diameter of 189 ft. and a depth of 41½ ft. and has a monolithic cylindrical exterior wall about 42½ ft. high from the bottom of the footing and 5½ ft. thick at the base. Concentric with this wall is an inner one 166 ft. in external diameter and about 16½ ft. high above the footing. The top of this wall is continuous with the concrete lining 12 in. thick which forms the bottom of the tank and is approximately a truncated cone. The annular space between the inner and outer walls serves to contain the water which forms a seal for the bottom of the telescopic cylindrical steel gas holder shell.

The outer wall is designed to take up maximum internal and external stresses which, however, were computed to require dimensions less than those necessary for practical considerations. It was therefore built to conform to the latter and thus presents a considerable excess over purely theoretical requirements. It is reinforced in the upper part with six sets of horizontal circular bands of square steel bars twisted. Each bar in the upper set has a sectional area of 1.25 sq. in. In the next three sets each bar has a sectional area of 0.75 sq .in. and in the remaining two sets each bar has a sectional area of 1.25 sq. in. In each set there are four complete rings or hoops, each made of several pieces of twisted steel with their ends overlapping about 32 in. and rigidly clamped together by U-bolts with tie pieces screwed close against the bars. The splices in the adjacent bars were made to break joints at least 2 ft.

Care was taken to avoid placing the bars of the same set in the same horizontal planes. Each successive bar from the inside outwardly was elevated a little so that the distances between them on centers would be somewhat increased and there would be less danger of direct horizontal communication between successive rings through which there might be produced a leakage. The joints of the bars were originally specified to have an efficiency of 90 per cent. of their ultimate strength without reliance on the adhesion of the concrete, but this requirement was finally waived in consideration of the results of a series of experiments made to determine how many inches of bar has to be inserted in concrete to develop its full breaking strength, and to determine where the failure to lap bars occurs. The results of these experiments showed that the breaking strength of the bar was developed by the adhesion of concrete when the bar was embedded for 32 diameters. The experiments with different classes of joints, and the pulling of parallel bars embedded in concrete without joint, showed that in every case of failure the trouble was caused by the splitting of the concrete. In other words, it was calculated that if the bars were lapped by one another 32 diameters, and if they were so attached together as to prevent the possibility of their becoming separated, they would fulfill all requirements. The ordinary U clamp was selected as being the simplest and most effective means of connecting the bars.

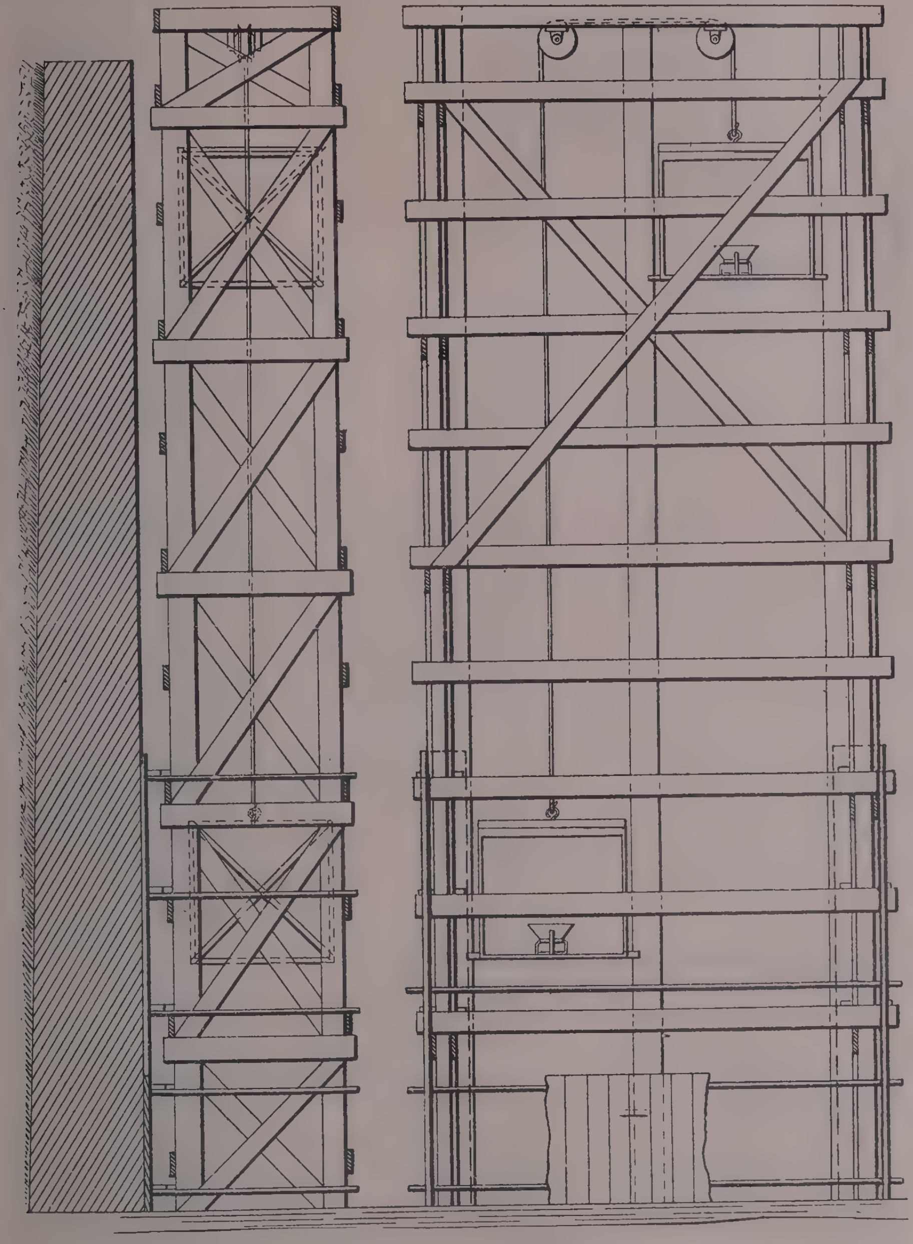
The top of the wall is finished with a 6-in. coping reinforced by a continuous horizontal sheet of 3-in. No. 10 expanded metal. The top of the coping is finished with a ½-in. coat of 1:2 cement mortar. On top of the wall there are horizontal seats for the 20 vertical columns of the gas holder guide frame. At each seat there are provided four vertical anchor bolts 2¼ in. in diameter and 19 and 20 ft. long. These rods have at their lower ends forged heads engaging sockets in wrought iron anchor plates bedded in the concrete with special care to avoid placing radially opposite heads in the same horizontal plane. The upper ends of the bars are set in sleeves 4 ft. long and 4 in. in diameter so as to provide for a slight lateral movement and allow for adjustment to the front framework. For this purpose lengths of ordinary stove pipes were advantageously used. On the bottom of the tank there are equidistantly placed 40 radial brick landing piers 13 in. thick and 7½ ft. long at the top, where they are capped with cut granite slabs 6 in. thick, accurately set to within ⅛ in. of the specified level.



Plan, Radial Section, and Detail of Outer Wall of Gas Holder Tank.

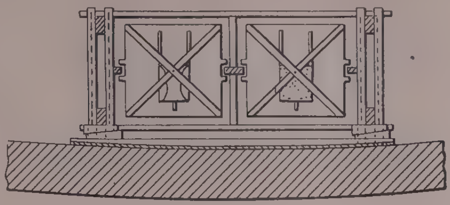
The inside circular wall has a minimum thickness of 30 in. and like the outside wall is made, as indicated in the general plan with buttresses in which are embedded the cast iron pipes providing communication between the interior and exterior of the tank. The conical bottom of the tank is provided with 72 rectangular pedestals made integral with it, supporting the vertical posts for the false-work on which the roof of the tank is to be erected as indicated in the semi-cross section. This concrete is built in two courses and is finished with 1 in. of 1:2 mortar. In the center of the bottom there is a 5x5-ft. solid mass of concrete 5 ft. deep in which is fixed a 4 ft. length of vertical 6-in. wrought iron pipe which projects a foot above its upper surface and has a cap on which the center point of the tank is accurately marked. The bottom of the annular trench in which the inner and outer circular walls are built is covered with 12 in. of concrete bedded solid on the rock and having the upper surface made level within 1 in. and finished with ½ in. of floated 1:2 cement mortar. It was required that the diameter of the tank should not vary more than 2 in. from the required dimensions and that the walls should not vary more than 1 in. from the vertical. The 1:2:4 concrete is made with Helderberg Portland cement crushed limestone, and limestone broken to pass a 2-in. mesh. Cement was furnished by the gas company in bags weighing 95 lb. each, which were rated at 9/10 cu. ft. Materials were mixed by bulk and measured in wheel-barrows gauged by the engineers.

At the site the rock was covered by a 13-ft. fill of earth containing some rubbish. The rock was of the micaceous character common throughout New York City, and was stratified in irregular layers dipping at different angles often as much as 45 deg., and in some cases was found decomposed. The site is about 600 ft. from the Harlem River and the original surface of the ground was about 10 ft. above high tide. Ground water level was about 10 ft. below the surface and a large amount of water was encountered which required constant pumping from the excavation. An annular trench about 26 ft. wide and 42½ ft. deep was excavated for the inner and outer walls and a portion of the material inside the trench was also excavated down to the limits of the tank bottom. The earth was excavated by pick and shovel and with ploughs and was removed by carts. Rock was excavated in the usual manner with Ingersoll-Sargeant steam drills and both it and the earth was handled by five boom derricks located so as to command the entire area of the tank. The earth excavation was sloped sufficiently to stand without sheeting, but the dip of the rock was so great that the seams and decomposed material which was interspersed between different layers made the inclined strata unstable and caused it in some places to slip into the trench. It was therefore necessary to brace it with heavy diagonal timbers in some places.



Panel of Falsework for Concrete Mould.

A large quantity of water flowed into the trench and was led through wooden troughs to a sump, whence it was removed by two large centrifugal pumps. When the concrete bottom was laid in the trench the top of the trough was covered with expanded metal and the trough was left in the concrete so as to provide a permanent drain. The sump was provided with a 6-in. cast iron pipe having an outlet through the conical bottom of the tank. The pipe was fitted with a valve adjusted to open in either direction according to the excess of pressure and thus provided against the possible upward hydraulic pressure against the conical tank bottom in case the tank should be emptied andthere should occur a heavy pressure from the ground water.



The magnitude of the exterior wall and the accuracy with which it was required to be built made its construction a difficult problem, which was finally solved by the use of a special form of centering and moulds which has been patented by the contractor. It consisted substantially of a skeleton wooden drum with the exterior cylindrical surface coincident with the interior surface of the wall. The drum was made with 40 radial vertical frames braced together horizontally by circumferential pieces and forming together a complete circular arch accurately located and dimensioned, which on its outer face received the adjustable segmental moulds for the inner face of the wall, the outer face of the wall being built against mould boards braced in any convenient manner against the irregular face of the trench.

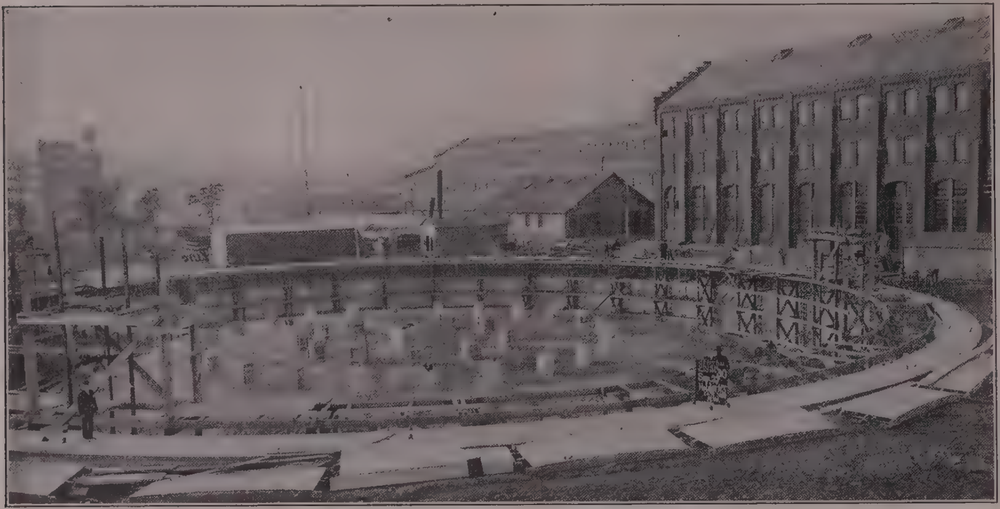
Each of the 40 radial frames was really an independent truss 6 ft. deep and 42 ft. high made with vertical pieces each composed of two 2x9-in. planks spiked together and breaking joints so as to form continuous chords for the truss. These pieces were connected by single horizontal and diagonal 9x2-in. pieces spiked across their faces. These trusses were all duplicates and the pieces for them were cut and dressed at the mills and framed together in horizontal planes at the site. In the plane of each truss a 6x6-in. yellow pine sill 8 ft. long was set on the concrete bottom of the trench and braced securely in position. It was accurately located by points determined with the transit and plumbed down from the surface of the ground.

Each truss was set in position by a derrick boom and the outer vertical leg was nailed accurately to the sill. The top of the vertical was set by the transit and its distance from the center was measured by a permanent measuring wire swiveled to the center point of the tank. The position of the sill in the bottom of the trench determined the location of the inner vertical member of the truss and fixed the latter in the radial plane. The first truss having been temporarily braced in position, the second one was set up in a similar manner and then the third and fourth, all of which were braced together by horizontal circumferential pieces nailed across their inner and outer faces as indicated in the engravings. As soon as four bents or trusses were in position they formed a stable tower and secured the succeeding bents as they were set up and carefully wedged so as to stand firmly in the required position.

Radial horizontal pieces nailed across the frames projected beyond the outer face and served to carry vertical iron guide strips against which a movable mould panel was seated. This panel was 5 ft. high and 14 ft. 11⅝ in. long and consisted of a segment of cylindrical surface corresponding to the inner face of the wall and reaching from one radial truss to the next. Enough of these panels were provided to form a complete circle and were moved up from the bottom to the top of the wall as the successive courses of concrete were laid. They were adjusted to within ⅛ in. of the exact required position by wedging them against the framework. A clearance of about 1 in. was left between the vertical edges of the adjacent panels where they rest against the guide plates, to allow for the expansion caused by wetting the dry timber. It was found that the expansion of the timber caused a maximum transverse displacement of about ½ in. for the radial frames, their adjustment was therefore made just before the horizontal holes were made through the vertical guide bars to locate the anchor bolts by which the tank guide rails were afterwards secured to the inner face of the concrete wall.

Sand, stone and cement were delivered by wheel-barrows to three Ransome concrete mixers located at different parts of the lot and provided with independent steam engines furnished by the manufacturers. The concrete was mixed very wet and was delivered from the machines in wheel-barrows to four elevators located in the main framework at equidistant points. Each elevator consisted of two balanced platforms running between guides in one panel of the framework. The platforms were attached to the opposite ends of a rope which took several turns about a drum at the upper end of the framework.

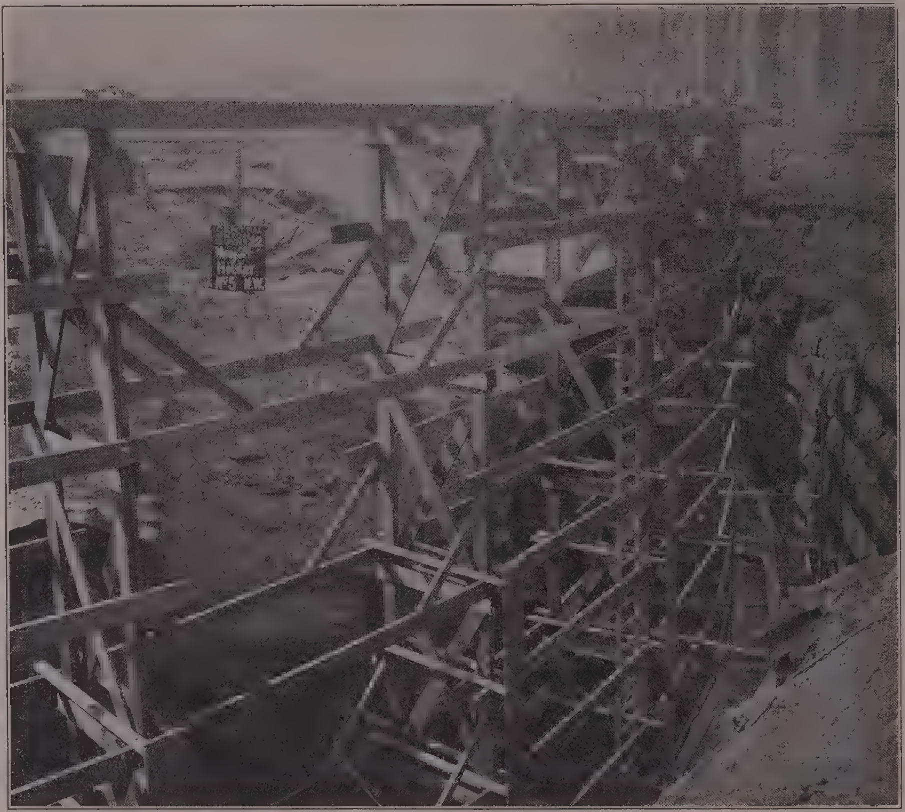
Two wheel-barrow loads of concrete were delivered to one of the platforms and were lowered by a man who controlled the drum by means of a friction brake. The descending platform pulled up the lighter platform on which were two empty wheel-barrows. The concrete was lowered to wheeling platforms cantilevered out from the outer face of the framework at successive heights of 5, 15, 20 ft., etc., above the bottom of the trench. On these platforms the concrete was distributed as required and dumped in the mould, where it was thoroughly rammed in 6-in. courses. By this method the concrete was wheeled to a maximum distance of only one-eighth the circumference of the tank.



Gas Holder Tank with Centering and Elevators.

The circumference of the wall was divided into three sections which were separately built up to a maximum height of 5 ft., no concrete ever being allowed to reach a greater height than this above the lowest point. After the concrete had set about 48 hours, the panels were successively moved up 5 ft. on their vertical guides so that the lower edges overlapped the concrete 12 in. and another 4-ft. zone of concrete was built, and so on until the wall was completed. The inner surface of the wall and the outer surface before back filling was thoroughly painted with two coats of stiff neat cement grout. After this had set the inner surface was finished by rubbing it smooth with corundum bricks which secured a very fine uniform texture.

The principal quantities involved include 18,000 cu. yds. of rock excavation, 6,000 cu. yd. and 80,000 ft. b. m. of timber in the false work. Excavation was commenced in July, 1904, concreting was commenced in April, 1905, and the outer annular wall was completed August 15, 1905. The average force of men employed being about 80. The work was designed and the execution was supervised by Mr. Howard Bruce, engineer of construction of the Consolidated Gas Company. Richard Deeves & Son were the general contractors and the excavation was done by Mr. Thomas Crimmins.



Details of Trusses for Centering for Concrete Moulds.

A Temporary Steam Supply has been secured in a novel manner by the United Railways & Electric Co., of Baltimore. At the beginning of the present winter it was facing the prospect of inadequate boiler capacity at the Pratt St. station, as the additional plant could not be completed in time for the heavy service of this part of the year. The company accordingly chartered a large passenger steamer, which was moored at a dock adjacent to the power station. She has four 250-h.-p. boilers, which are capable of overload up to a total of 1,500 h.-p. These were disconnected from the engines, and piped to an 8-in. manifold on the edge of the upper deck of the steamer. A 10-in. pipe was connected to the header in the station and run to a manifold supported on a trestle at the edge of the wharf. These two manifolds were then connected by a series of flexible copper pipes.

Railroad Construction in Northern Mexico.

The accompanying account of railroad construction in Mexico, the class of labor available and the conditions under which the work is carried on, is taken from information furnished by Mr. Edward Wright, division engineer of the Mexican Central R. R., at present stationed at Tuxpan, State of Jalisco, Mexico. Mr. Wright is engaged in construction work on the Manzanillo extension of the Mexican Central R. R., his division being located in the Tuxpan Canon, about 60 miles from the Pacific coast and at an elevation of 3,000 ft. The country at this point is exceedingly rough and wild, making work very difficult. While the line is of very heavy construction the methods employed differ little from those in vogue in the United States.

The railway is located but a few miles from the volcano Colima, which, though at present quiet, is frequently in such a state of activity as to keep those living near it in a constant condition of restlessness. The soil in this part of the country is supposed to be of volcanic origin, and though existing in quite a variety of forms, is generally designated "tepitate." It is very fertile, but so compact that cuts can be made through it with ½ to 1 slopes, and powder is required to shake up the material before moving.

The labor employed in this construction work consists of Indian peons and Spanish half-breeds, who handle the excavated material with wheel-barrows or carry it in large baskets strapped to their backs. The peons are fond of working in large groups and will start to work early in the morning without breakfast, after their tarea or task for the day has been assigned to them by the foreman in charge. About 9 o'clock their breakfast, consisting of tortillas, or corn cakes, and beans, is taken to them on the work by members of their families. The tortillas must be made fresh every day, and long before daybreak the women must be up grinding the corn.

The peons, while glad enough to work in large companies, refuse to live in camps as is done by railroad construction forces in this country. The majority of them have wives and build for themselves small grass-thatched huts, which they leave standing when it becomes necessary to move. In moving from place to place, which is frequently necessary in this class of work, the peon packs his few earthly belongings in a basket strapped on his back, while his wife and children, if he has any, follow along on foot behind. The women, like the men, prefer to work in groups and are very much given to gossiping. The men are exceedingly jealous, and all carry large knives concealed in their clothing which they do not hesitate to use on slight provocation.

The laborers are paid every two weeks, and after spending the small amount necessary for food the balance is usually devoted to drink. Until their money is all spent it is out of the question to expect these people to do any work. They give strict observance to all saints' days and national holidays, which come in such rapid succession as to keep the contractors wondering how many men they can count on even a day ahead.

All railroad construction in Mexico is carried on under the direction of Americans, and the pay, according to Mr. Wright, is slightly better than in the United States, with the additional advantage that no time is lost on account of adverse weather conditions. The climate in this portion of Mexico is too warm for frost, the temperature varying but little during the year. During April and May the days are quite hot, but from one year's end to the other the nights are cool enough to make a blanket or two desirable.

According to Mr. Wright, everybody in the Republic knows everybody else, and the conditions are so agreeable that after a man has lived there long enough to overcome his first homesickness and to master the language partly, he is rarely contented to live elsewhere. Mr. Wright says further, however, that few Americans can for any length of time stand Mexican food, which consists of "meat, then more meat, with beans for dessert." Vegetables, he says, are rarely used and fruit, it is believed, produces fever and ague. The people also have an idea that water in the morning is harmful, and it does not add to one's appetite to know that unwashed hands have prepared the breakfast. In the case of the engineers engaged on the Manzanillo Extension work the kitchen is presided over by a Chinese cook, who supplies an attractive variety of clean and well-cooked food.

Drainage of Outer Wall Trench.

Concrete and Reinforcement for Outer Wall.

The divisions or residencies on the Mexican Central work are manned by an engineer, an instrumentman and a masonry inspector. The chainmen and rodmen are all natives and are said to be fairly capable at this work, though they are much slower than Americans in the same positions. The metric system is used and, according to Mr. Wright, is better liked than the English system of feet and inches, especially as the men are able to think in meters and are not under the necessity of mentally reducing to feet.

WRITTEN ORDERS for any changes in plans and specifications forming part of a contract should always be demanded by a contractor. Sometimes the courts will uphold verbal agreements, as was done by the California Court of Appeals in Wyman vs. Hooker, 83 Pac. Rep. 79. In this case, where extra work on a building was performed with the knowledge and consent of the owner and his agent, and they waived a written stipulation and a separate written estimate, provided for by the contract, by orally agreeing to continue the work without such estimates, the court rules that the owner could not afterwards repudiate the work because the estimates were not furnished.

The East Jersey Pipe Co.'s Lock-Bar Pipe Plant.

Adjacent to its plant in Paterson, N. J., where over 25,000 tons of pipe up to 72 in. in diameter have been made for the East Jersey Water Co., and many thousand tons of large riveted steel water pipe on other contracts, the East Jersey Pipe Co. has installed a plant with new and special machinery for the manufacture of large steel pipes without riveted longitudinal joints. This pipe has the patent lock-bar joint which is made with a heavy H-shape bar closed down on the upset longitudinal edges of the plates, thus avoiding all punching, drilling, reaming, riveting and caulking in the longitudinal joints and dispensing with the presence of all of the rivet heads in the interior of a pipe, which diminish the capacity of the pipe by several per cent. The joints are watertight even under heavy pressures and are so proved by tensile tests sometimes strong enough to tear the plates, giving consequently, a 100 per cent. joint. The process of manufacture is simple and the pipes can be made more rapidly than riveted pipes of the same size. Contracts have been awarded for many tons of these pipes for different water works and their successful execution, now in progress, is the only instance in the country where these pipes have been successfully manufactured on a commercial scale. The present equipment of the shop provides for the manufacture of pipes from 16 in. to 10 ft. in diameter and has been completed only a short time.

Plates of a thickness of ¼ in. to ½ in. and up to the standard length of 30 ft. are delivered on flat cars, which are run into the shop and unloaded by overhead girder cranes which afterwards place them singly and horizontally on the bed of the upsetting machine where one edge is firmly secured by a full length movable plate girder clamp with vertical web which is forced down by powerful hydraulic jacks. A traveling head, movable from end to end of the machine adjacent and parallel with the clamping girder, is driven by a longitudinal screw at the rate of 25 ft. per minute and carries a set of five horizontal planing tools which in successive cuts at one operation remove up to ½ in. of the edge, trimming it to the exact required size. They are followed by a set of five grooved rollers about 3 in. in diameter with vertical axes set so that they successively upset the metal, the total upset being proportioned to the thickness of the plate, and producing the thickened double bevel edge necessary for the lock joint. While one edge of the plate is thus upset the other edge is clamped to the bed of the machine with hand screw jacks and as soon as it is complete, which for a 30-ft. plate 6 ft. wide and ½ in. thick takes less than two minutes, the plate is reversed in the machine and the opposite edge is also upset.

From the upsetting machine the plates are taken by girder cranes to the crimping machine, an hydraulic press of 150 tons capacity which has dies from 4 ft. to 8 ft. long to curve the edges of the plate to the required radius in successive sections of corresponding length. This operation is necessary to prevent the upset edges from being injured in the bending rolls of ordinary boiler maker's type to which the plate next goes and from which it emerges curved 180 degrees for pipes up to 6 ft. in diameter; for larger pipes it will probably be curved 90 degrees and four pieces and four longitudinal joints be required for each 30-ft. section.

The curved plates are taken by girder cranes to the assembling floor where they are matched together and their edges are fitted into the rolled lock bars which engage them easily and are clamped on by solid steel rings about 5 ft. apart which enclose the pipe and are wedged tight against the bars.

The assembled pipe is delivered by the girder crane system to the closing machine which has large and heavy steel bolts with an adjustable cross-head, and below it, about level with the floor, a 750-ton hydraulic cylinder with a vertical plunger. The cross-head is set to provide clearance between it and the plunger for the pipe and a pair of adjustable die blocks mounted on a long and massive hollow horizontal steel arm or mandril and operated by a small vertical hydraulic cylinder is inserted in the pipe. The operator extends the plunger of the small cylinder so that the die blocks engage the inner surfaces of the top and bottom lock bars and act as a holder-on. Then the large depressed hydraulic cylinder outside is operated and reacting through the inside cylinder against the dies in the cross-head, closes the open flanges of the lock-bars pressing them solidly down on the curved plate in 8-in. lengths. The machine is very rapid and as no time is lost except in removing the clamp rings and wedges the pipe is quickly carried through the housing on its horizontal roller carriage and both longitudinal joints are simultaneously made in a short space of time.

The pipes are placed on the trimming skids, the ends of the lock bars which project beyond the pipe are cut off and the bars are trimmed thin at the ends where buttstraps are used to form the circular joints, and the inner surface of the bar is flattened at the end to afford bearing for a rivet through the buttstrap. A hydraulic punch, suspended by a differential hoist, punches rivet holes in the end of the pipe for the splice and the pipe is taken to the riveting shop and the buttplates riveted on as in any riveted pipe work. It was at first thought that the forming of the pipe would produce unwarrantable variations in the rivet pitch if the holes were punched before the pipe was jointed, but recent trials have demonstrated otherwise, and in some cases the ends of the plates are punched flat instead of as above described.

Each pipe is taken on trucks to the testing house and there angle iron rings are secured in each end by bolts through the butt splice plate field rivet holes. Heavy dished heads with rubber gaskets are set against the insides of these flanges and the pipe is filled with water delivered from a Worthington pump of a sufficient capacity to give any desired pressure.

On the 48-in. x 7/16-in. pipe now being made for the Water Board of Wilmington, Del., the required test pressure is 200 lb. per sq. in. and recently a test was made on one of these pipes up to 400 lb., at which pressure, one of the testing heads buckled and broke the pressure pipe connection; the pipe itself showed no signs of distress whatever and apparently would have stood a much higher pressure; this test was a very interesting one and was made in the presence of Mr. Theo. A. Leisen, the engineer of the Water Board of Wilmington, and Mr. A. W. Cuddeback, the superintendent and engineer of the Passaic Water Co. of Paterson, N. J., who has since placed an order with the company for 11,000 ft. of 48-in. and 42-in. pipe, and several of the officials of the East Jersey Pipe Co.

After testing, the pipe is placed on trucks with one end engaging the flue opening of a furnace using oil fuel. A blast is turned on and the furnace flame is driven nearly through the pipe, escaping with the heated gases at the opposite open end. This heats the pipe thoroughly and uniformly in a very few minutes to the temperature required for the dipping bath. The pipe is then immediately lifted by an overhead girder crane and lowered with its axis vertical into the bath, removed after a few minutes, and loaded on a flat car ready for shipment.

The dipping tanks consists of a vertical cylindrical outer shell 12 ft. in diameter and 33 ft. long, set in the ground, with the upper end projecting a few feet above the surface. The lower end rests on a concrete footing, which closes it tightly and also supports a concentric inner steel shell 10 ft. in diameter which is filled with the asphaltum preservative liquid. A coil of steam pipes between the inner and outer shells, and another arranged around the inner surface of the inner shell, heats the bath, and a third coil inside a 12-in. pipe in the axis of the tank may be used to heat the bath still more if necessary. The center pipe and coil are removable and the former serves to reduce the quantity of asphalt required to fill the tank.

With the plant above described and a force of about 40 men, about 50 tons of large pipe can be made, tested and shipped daily, running single turn. Contracts are now on hand sufficient to keep it in operation for a long time and it is intended to increase its capacity materially.

Poppet Valves are being tested upon a locomotive in Germany in connection with superheated steam. Separate inlet and exhaust valves are used, the valve motion operating the poppets by cams.

Methods of Raising an Elevated Railroad Structure.

By W. F. Graves.

A rather interesting and unusual piece of work is now being accomplished by the South Side Elevated Railroad in Chicago, in the erection of a third or express track parallel to the two existing tracks of the company from 43d St. to 12th St., a distance of about 3.3 miles. The structure occupies the private right of way of the company adjacent to an alley from 43d to 40th St., north and south, thence west by a curve of 100 ft. radius for 90 deg., along the south side of 40th St., which is occupied by the double track of the Chicago Junction Ry., to the west side of the alley and adjacent thereto, between State St. and Wabash Ave., thence north, crossing the Chicago Junction Ry. on a curve of 100 ft. radius for about 90 deg., on their own right of way to 12th St.

The ordinance covering the express track improvement provided for paving the alley and right of way for this distance. In order to accomplish this it became necessary to tear down the old stations, which were brick buildings, the floor line being on the street level, and erect stations suspended from the structure. To obtain head room for the paved roadway beneath the suspended stations, as well as to cross the tracks of the Chicago Junction Ry., which are to be elevated on masonry retaining walls, it became necessary to raise the elevated structure from four to ten feet at these places, and to replace the ordinary deck girder construction work with through spans at the railroad crossing and stations, thus giving about four feet additional head room.

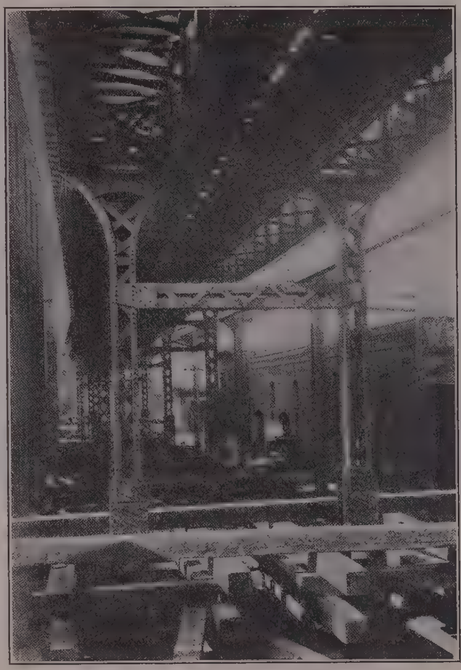


Fig I. Showing Type of Column Extension.

The old structure consists of spread top columns, of two 15-in. channels laced, and spread at the top to 5 ft. to receive the deck track girders, and at the bottom inserted in a cast base resting on a masonry foundation. In the casting are recesses 21 in. deep, the shape of the channels and ¼ in. larger, in which they rest, and are fixed by a rust joint. The casting is held in position on the foundation with four 1¼-in. anchor bolts. The column, up to the top of an horizontal tie plate 8 in. wide, the bottom being uniformly 1 in. above the casting, was filled with concrete to shed water. At the stations, cross-girder construction took the place of the spread top construction; to the ends of the cross girders were spliced the cross girder of the new structure, thus making additional load for the old foundations and at these points the 8x8-in. pedestals were replaced with pedestals having a base 10 ft. square, this being done while the structure was on temporary supports.

In order to clear certain property and lengthen the radii of the 100-ft. radius curves mentioned to three-centered compound curves having a terminal radius of 500 ft. and a central radius of 187 ft., it was necessary to shift the alignment of the old structure to the south about 9 ft. at 40th St. and Wabash Ave.

The work of raising and shifting the structure and renewing the foundations was accomplished in the following manner: An excavation about 4 ft. square was made around the base of each column, exposing the casting and capstone of the foundation, the nuts on the anchor bolts were taken off, and 5 ft. on either side of the column a substantial foundation of 12x12-in. timber blocks about 5 ft. long was placed to receive cribbing of 12x12 in. timbers, which were built up from three to five feet around the structure. On these was placed a 12x16-in. for the entire length, and on these, running lengthwise of the structure also, were placed six 9x18-in. Oregon fir stringers having a span of about 15 ft. clear. On these stringers the regular 12x12-in. cribbing and framed bents were placed. Extreme care was exercised in taking out the old foundations and excavating for the new, to keep the excavation tightly boxed with a 3x8-in. hard maple on account of a great deal of quicksand being encountered, and a tendency from the concentration of weight, to cave the hole. When the required height was reached the castings were rammed off with two 20-ft. sections of 90-lb. T-rail, suspended from ties on top on either side of the column.

On these were placed tower bents of 12x12-in. timbers, framed with 4x8-in. bracing and bolted, the bottom flange of the track girder setting on the cap, within the cribbing. Before the bents were placed, the steel column was placed, preparatory to being riveted on the shaft of the old column forming the permanent supports of the structure. The sills of the bents were allowed to project about 2 ft. from the posts, to receive the head of a hydraulic jack. Under each end of the sills a 20-ton jack was placed, making eight to each steel bent, the base of the jacks resting on the projecting ends of the cribbing, and at times jacking was done on the pieces forming the cribbing. The difference in the 2 or 4 in. being reached, oak blocks were inserted under the cross timbers of the cribbing, and the jacks released. This operation required from two to four minutes. The next bent was treated likewise, great care being taken to keep an easy grade run off ahead of the jacking. When a height of 12 in. was reached on the small blocks a 12x12-in. timber was inserted replacing them, thus keeping the structure on a substantial cribbing.

Where new foundations were put in under the old structure the method of jacking was the same, the cribbing, however, being built of 12x12-in. blocks placed lengthwise of the structure and 7 ft. from the column, and extending across the height of the jack and the space between the bottom of the sill. The timber from which the jacking was done was made up by 4-in. oak blocks placed in the head of the jack; this did not usually exceed eight inches.

The maximum height raised at each time was four inches, but this was kept down to no more than two inches when there was cross girder construction, owing to excessive stresses in the riveted connections, two lifts being made through this construction to one through the ordinary

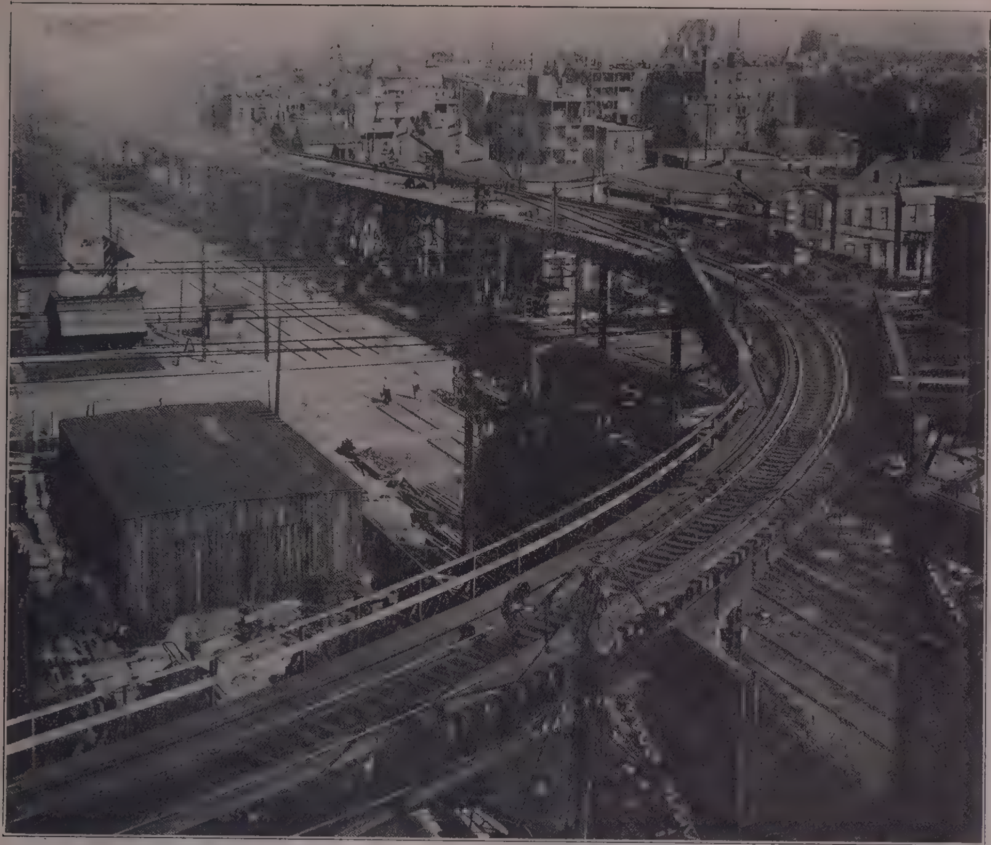


Fig. 2. Manipulation of 100-Ft. Radius Curve

spread top construction.

When jacking at any bent was commenced a flagman on the tracks above stopped trains in both directions, none being allowed to pass over while the weight was on the jacks, and when a column with a block and fall being raised and dropped on each side of the projecting edge of the casting simultaneously. The rust joint, in the majority of these castings, held remarkable well, the cost in specific instances for ramming them off being as high as $40.

Where the structure was shifted the cribbing was built up and bents placed in the same way as when new foundations were required, the difference being that two 12x12-in. sticks extending across the width of the structure and over its new position were placed under the 9x18-in. stringers, and when the required height was reached, about 10 ft., the top one was raised sufficiently to permit placing turned oak rollers 8 in. in diameter between them. The movement was made by use of ordinary stone jacks placed against dead men. This lateral movement of 9 ft. required about one hour to accomplish.

The raising of the structure, reconstruction of the two large curves, erecting new stations and various manipulations of the old structure was done under a traffic of trains each way running on a maximum interval of 3½ minutes without serious delay, in spite of the fact that ten single track train movements were required in the reconstruction of that portion of the structure between Indiana Ave. and 39th St., a distance of 2,700 ft.

In the accompanying photographs. Fig. 1 illustrates the type of column extension used and shows the structure on its permanent supports, the cribbing having been partly taken down. Fig. 2 illustrates the manipulation of the 100-ft. radius curve and crossing of the Chicago Junction railway. The point at which the structure was shifted still has the cribbing under it and can be seen in the upper portion of the picture. Single track service is being used on the north-bound track of the new curve, and crosses over to the new tangent on the south-bound track, the old structure having been wrecked and no track yet laid on the middle and north-bound tracks. The curve owing to the change in direction of the initial tangent now contains 92 deg. 10 min. Fig. 3 illustrates the method of rolling the old structure over to its new alignment parallel to the new structure, which can be seen at the right, with framed bents on either side of the column to give it rigidity under train service, which has been single tracked to permit manipulating the existing tracks. Fig. 4 shows the old structure undisturbed and the new erected to the end of a station platform which interferes with further erection.

Water Main Accidents.

Water main accidents due to heavy blasting in the vicinity of such pipes are a source of serious damage which foremen ought to consider carefully. The destruction which a break in a large main will cause is very great, as a recent accident of this sort at 150th St. and Convent Ave., New York, showed very clearly. The break occurred in a 36-in. main near the top of a hill, and in a few minutes after it happened the steep avenue was flooded over a foot, the water running into the cellars of the houses. At the bottom of the hill the depth was four feet in a couple of saloons and the men assembled in them had to climb upon the bars to escape the water. In one of the houses the tenants were so overwhelmed by the flood that a hook and ladder company was called out and the people taken from the upper floors by ladders. The electric conduits of the street railways were flooded and the passengers in the cars were taken off in high-bodied wagons. The accident is a good example of what may happen when exceptional care is not taken in all blasting operations in the vicinity of such pipes. Some contractors prefer to take the risk of damages of this sort in order to push their work rapidly, believing that the occasional destruction which results is more than balanced by the speed with which the construction is carried on. It may be questioned, however, whether it is safe to run any risk whatever when the mains in the vicinity are of more than very moderate size, and there are a good many contractors who believe that such risks should never be taken when there are pipes of any size whatever in the immediate vicinity.

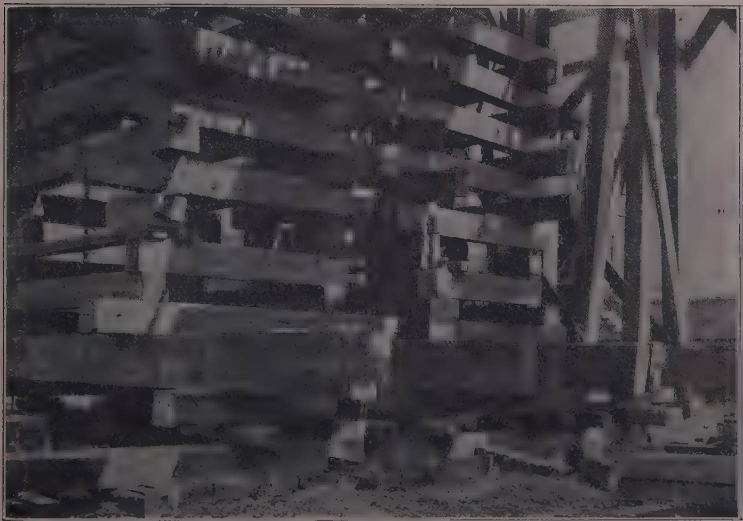


Fig. 3. Rolling Old Structure Over to New Alignment.

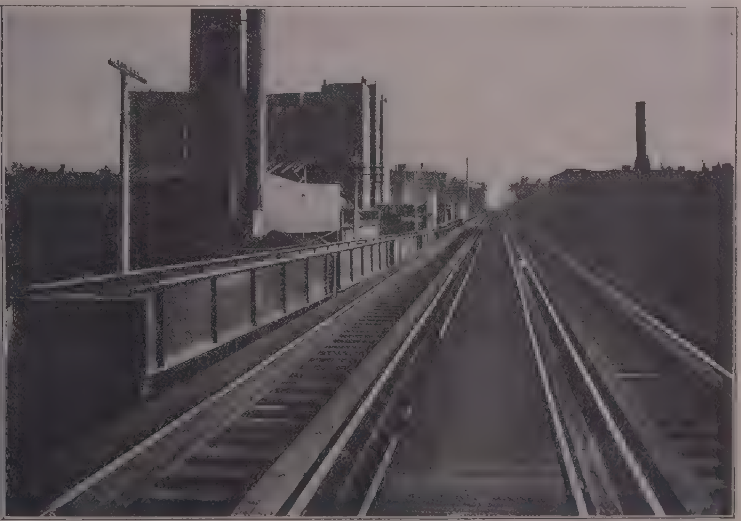


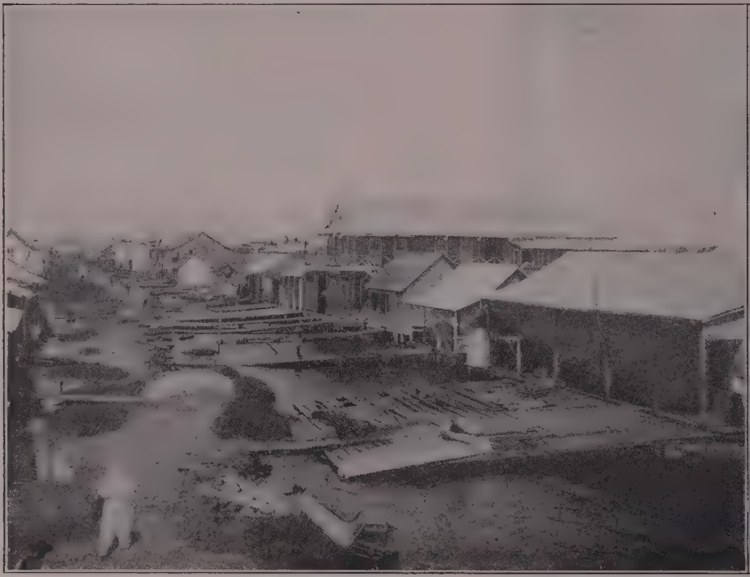
Fig. 4. New Structure in Place Beside the Old.

Some Concrete Work in Panama.

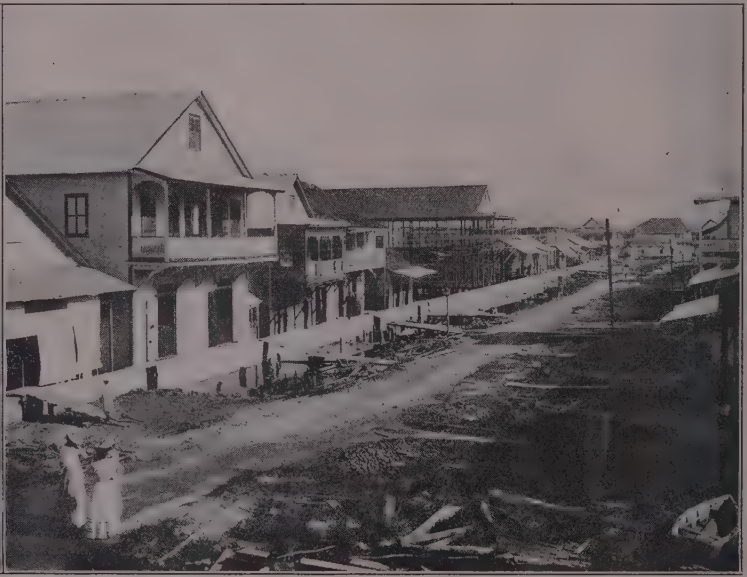
By Howard Egleston, C. E., Bocas del Toro.

Among the public works for which appropriations were made by the first Panama Congress in 1904 was the sanitary work at Bocas del Toro, a seaport situated 140 miles north of Colon, on the Atlantic Coast. This place is built on an island at the main entrance to the great Almirante Bay, one of the finest anchorages in the world. In olden times this was a favorite rendezvous for pirates, their intimate knowledge of the many passages between the islands surrounding the Bay, making their escape from pursuing men-of-war an easy matter. Later on, it became a favorite refuge for slaves escaping from the various West India Islands, and it was not till the year 1835, that it came under a regular government, Colombia in that year sending officials to govern the place.

The chief and almost only industry of the place is banana growing. Bocas is the largest shipping port in the Republic, and one of the largest in Central America; from it were shipped in 1904 3,298,240 bunches, and in 1905 about 2,800,000 bunches. The falling off was due to a disease that has broken out in many plantations. The cultivation of bananas began in 1890. In 1901 a consolidation of the various companies and individuals engaged in shipping the fruit was effected under the name of the United Fruit Co. Under their management the price paid for fruit has declined from 90 cents per bunch to less than 25 cents for "firsts," 12½ cents for "seconds," and 7 cents for "thirds," with the natural result that most of the independent growers have sold their plantations to the company.



View of Street the Day Before Work Began.



A Later View of the Same Street.

So much to introduce the place. The first of the sanitary works to be done here consisted of building a sea wall about twelve hundred feet long, three and a half feet thick at the bottom and two and a half feet thick at the top. This wall is more a retaining wall for the street when it shall have been brought up to the level of which the city is to be raised. The location of the wall was thoroughly nasty, as one may judge from Fig. 1 taken the day before work began. The shore here had been the dumping place for the filth of the town since the year 1, and, starting above tide, we dug down again and again, until the men stood up to their chins in an indescribable ooze of black liquid filth.

Sheet piling, made of three thicknesses of 1x10-in. boards, was driven for the walls of the form. Inside of these walls were placed other boards in such manner as to give a section 0.75 m. wide on top, 1.00 m. wide at a depth of 1.00 m., and 1.1 m. wide below that. The face on the land side is vertical, with an offset of 5 cm. 1.00 m. from the top; there is an offset of the same width on the sea face, separating the battered upper part from the plumb lower portion.

We had great difficulty in keeping our form in a straight line. The mud was not stiff enough to hold the boards in place, and when we struck sand we found it packed so hard that it was impossible to drive the piling far enough into it to give stability. Posts, driven every few feet, with stringers spiked on top of them, braced from houses wherever possible, gave as good results as could be expected under the circumstances.

The curve was the most difficult part of the work, yet from its form I was able to get better lines, and greater stability of the forms, than in the straight work. To get my curve I put in posts every eight feet. Against them I nailed a built-up timber something over 200 ft. long, composed of three thicknesses of 1x4-in. stuff. This gave me a very true sweep, and on this, all the woodwork of my form for the curve was based.

Of the labor question, I have this to say: I have had no difficulty in getting enough laborers for the work, and have found them, the Jamaica negroes, quite as good workers as any that I have employed in other places. In a country where the necessities of life are so few as here, one cannot expect the same devotion to work as in the North. When there is no winter to provide against, no warm clothes to buy, it is not a serious thing to be out of work a part of the time; therefore you cannot drive your men as hard as you can when they must work or suffer. If one thinks for them, and is always on the alert to provide work for them the moment they finish the job they are on, he can get quite as good returns in work from the Jamaica negro as from any other laborer. The amount of work turned out depends more on the man in charge, than on the laborers.

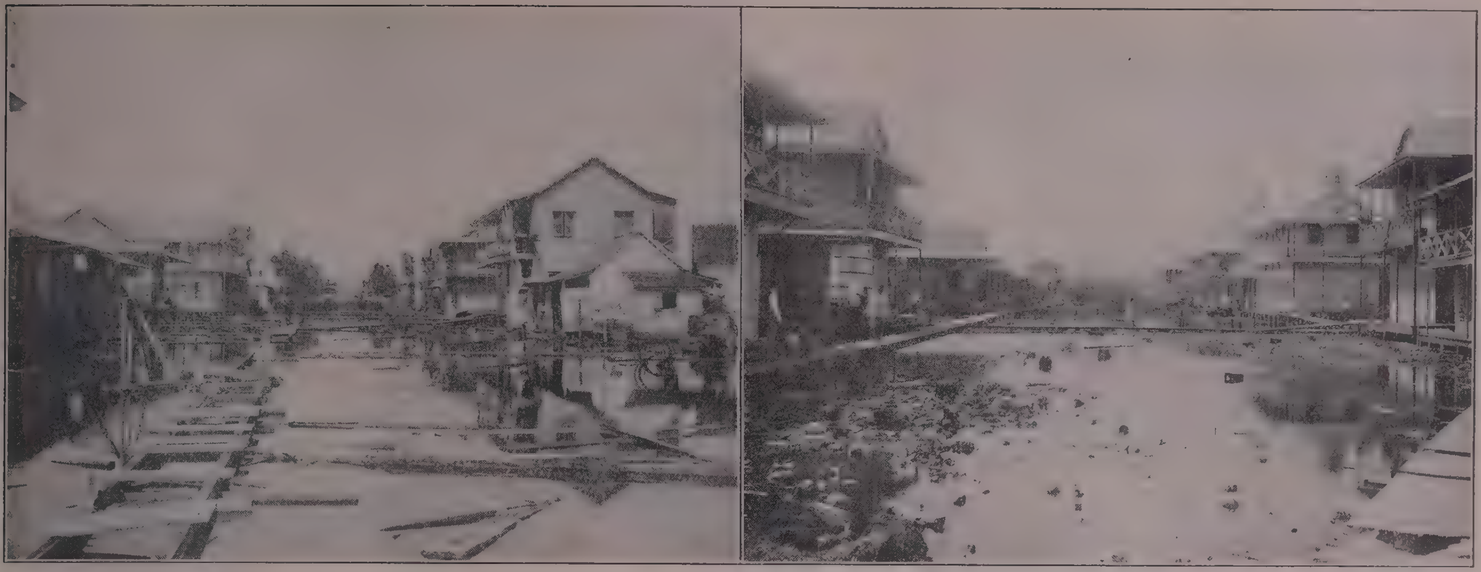
My experience here has been that I get better results with negro foremen than with white foremen. I tried white men at first, but not being able to get men of the right class, I promoted some of my best workers among the negroes, and the result was exceedingly satisfactory.

The cost per cubic meter of my concrete work was altogether too high, averaging nearly $14. This should not have been necessary, and occurred only through my being misled in regard to the materials I would find here. I went into the competition for this work at the last moment and there was not time to make a trip of inspection to this place. I was therefore compelled to rely on information given me by a native engineer who had lived in Bocas many years. He assured me that I would find gravel plentiful and that it could be brought to the work at little cost. I therefore made no provision for a stone crusher. On reaching Bocas to begin work I found soon that I should need a crusher and took steps to get one, but blunders on the part of a manufacturer in the United States made necessary the exchange of several letters, each one taking two or three weeks for an answer, so I was compelled to do the best I could by breaking with hand hammers. The limited supply of stone made it impossible to use a mechanical mixer, and I was compelled to mix by hand. I make this explanation that no one should think that I claim that such work should cost here such a sum as it cost me; with proper preparation and machinery, there is no reason why concrete should cost here more than eight or nine dollars.

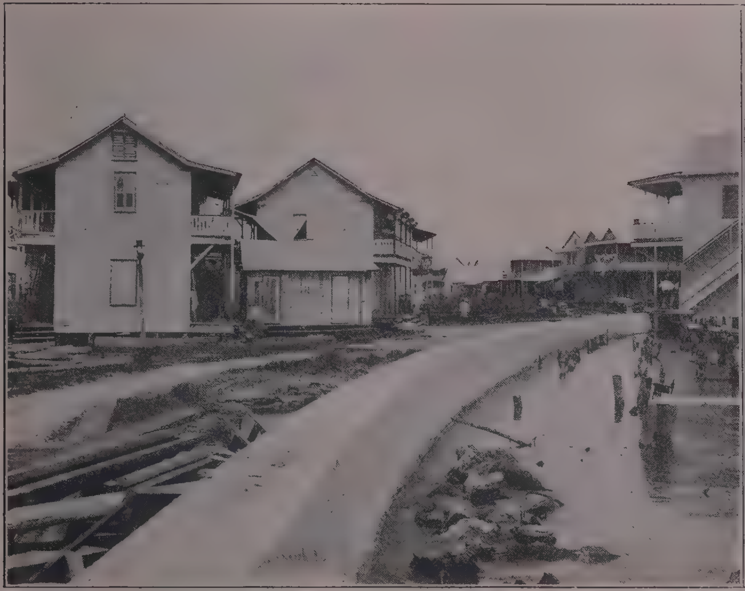
I used Vulcanite cement exclusively, purchased through Mr. Allen Tupper, Southern agent for the company at New Orleans, La., and have to report most excellent satisfaction in all respects. At first the native engineers, being only familiar with English, French and German brands, were very suspicious, one old Italian who was acting as inspector, insisting that, all bags must be sealed at the factory with a lead seal. But all friction worked off at last, and now everyone is convinced that a really first class material was used.

I brought most of the cement down in bags, having frequent small shipments made, but I do not think I would do it again. Had the work been stopped for a month by rain, as may any time happen here, I should not have put a high value on the cement I had in stock. It is much safer in barrels.

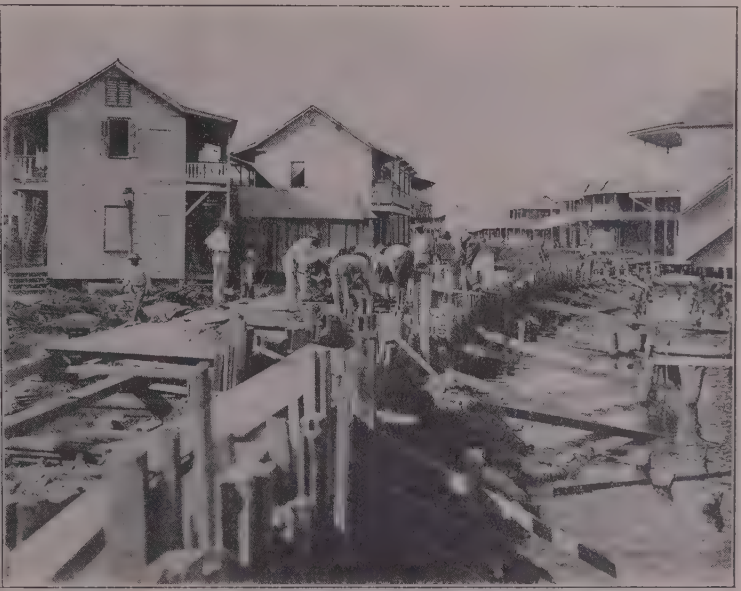
In making concrete I used throughout unwashed ocean sand and salt water to mix with, except in some cases when I needed quick-setting concrete, then I used the same sand, but mixed with rain water. This was not a matter of choice, Bocas has no water works, no river, no brook, but depends entirely on the rainfall for water for all purposes, and it was impossible to get a sufficient quantity of fresh water for mixing. Of



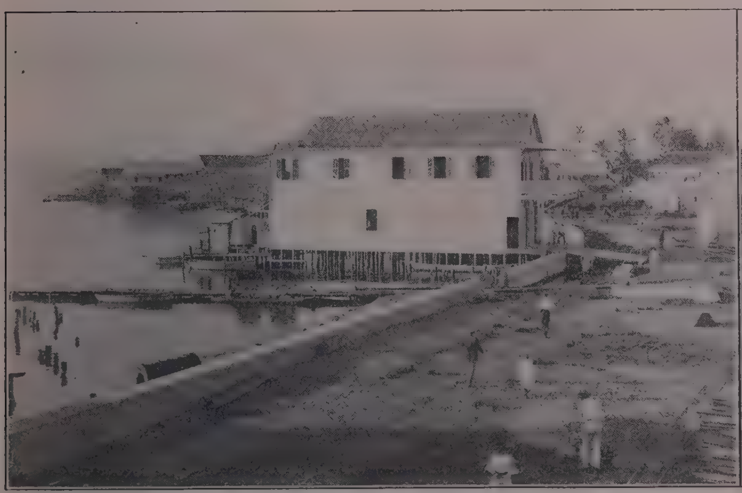
Two Views of the Condition of Streets Before Filling Was Commenced.



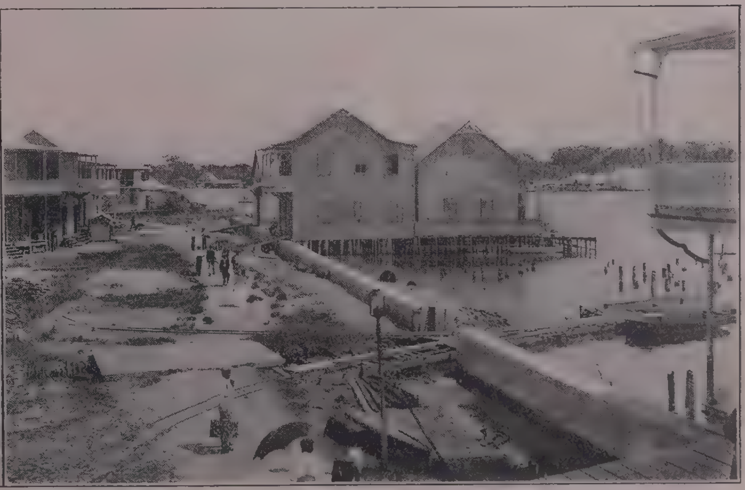
View of the Beginning of the Curved Wall.



Carpenter Work on the Mould for the Curve.



View of the End of the Curved Wall.



The Final Tangent of the Wall.

course the concrete set more slowly on this account, and when there was wave motion, this was a disadvantage to the work. The concrete has hardened in a most satisfactory manner, and it is now almost impossible to make any impression on it with a pickaxe or chisel.

Pumping Crude Oil through corrugated pipes with water is being tested by the Southern Pacific R. R. in an attempt to overcome the difficulties of pumping oil to long distances. The water is said to form a shell around the oil and the grooves in the pipe to cause the water and oil to advance with a rotary motion. The water is removed from the oil at the end of the line by a centrifugal separator. The pipe used is 8 in. in diameter, corrugated on the inside with six ½-in. grooves, 3/64-in. deep, which make two complete revolutions in a 20-ft. length.

General View of Neals Shoals Plant from Above.

CONSTRUCTION OF THE NEALS SHOALS POWER PLANT ON BROAD RIVER, S. C.

By Francis L. Sellew, New York City.

The increased activity in the development of hydro-electric plants in the South, where favorable locations for this class of prime movers abound, leads the writer to believe that a description of engineering details and methods of construction employed on a plant recently completed, may be of interest.

In the spring of 1903 work was begun on a dam and power house for the Union Mfg. and Power Co., of Union, South Carolina. The power generated is to be used in Union and its vicinity, where there are five large cotton mills, a knitting mill and a municipal lighting plant, which will take the bulk of the current, and numerous other interests requiring power in smaller units. The plant is located on "Broad River of the Carolinas" about 15 miles from the center of distribution and some 50 miles above Columbia, the State capital, at a point locally known as Neals Shoals. Here the river has a normal width of some 700 ft., a drainage area of about 3,000 square miles and a dry weather flow approximating 1,500 second-feet. The lake created by the dam is 10 miles in length, and after advantage is taken of the storage about 7,000 h.-p. will be delivered on the switchboard.

The general plan of the plant is shown by Fig. 1. The dam is about 1,000 ft. in length, founded upon rock for the entire distance from the ledge outcrop at its easterly end to the power house. Near the easterly terminus provision is made for a lock in the structure should the future navigation interests of the river demand it. The entrance to such a lock is shown in Fig. 2, the gap being closed by a timber crib filled with rock, which can be readily removed if a lock should be constructed. Adjacent to the power house are five sand gates, as shown in Fig. 3, with operating mechanism located on piers well above the flood level, to draw off deposits from the forebay. The latter view was taken toward the end of a freshet which visited the work early in July, 1905. The profile of the dam which is spillway for the entire length is shown by Fig. 4. The rollway and the face were designed to be in contact with the passing water throughout the entire fall of the sheet. This theoretic profile meets the actual conditions almost perfectly as indicated in Fig. 2, which shows the water passing over the completed structure in an unbroken sheet excepting such slight disturbances as are due to the roughness of the masonry.

The dam has faces of quarry-faced rubble, a heart of concrete in which very large stones are embedded, and a concrete rollway. An excellent idea of the character of the masonry may be gained from Fig. 5, a view taken during construction and Fig. 6 which shows the completed dam. The face courses were laid first and then the backing of large stones was placed, each stone being carefully bedded in rich Portland cement mortar, and not nearer than 6 in. to any adjacent stone. After all the backing in a course had been placed, the spaces between the stones were fully filled with concrete, thoroughly rammed into place, care being taken to leave the tops of the stones projecting far enough to give a proper bond to the course above. These projecting stones were especially large and numerous in the top course in order that the rollway concrete should be thoroughly united to the mass below. When the pond was filled there were practically no leaks, the downstream face being only a little damp, which dampness gradually disappeared.

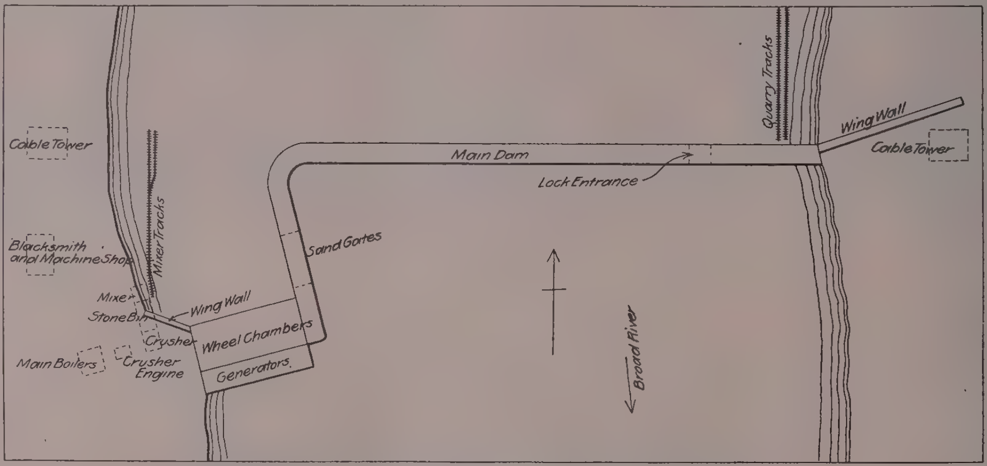


Fig. 1. Plan of Construction Plant at the Neals Shoals Dam.

The power house which adjoins the dam and is a continuation of it into the hill at the westerly end is composed entirely of reinforced concrete, excepting the roof, which is an asphalt and gravel covering upon plank supported by timber trusses. The easterly and southerly walls have embedded in them 18-in. steel beams, 35 ft. in length, reaching from well below the floor to the roof. The northerly wall has similar but shorter 12-in. beams reaching to the roof. These beams are about 6 ft. on centers and those in the northerly and southerly walls carry brackets on which rest the track supporting a traveling crane. Between these vertical beams horizontal corrugated bars are placed, the vertical spacing of which increases as the top is approached. The floors adjacent to the machinery are also reinforced by steel beams and those of the wheel chambers are supported by cast-iron columns. Corrugated bars are used for further reinforcement of all walls, floors and piers. The general arrangement of the reinforcing metal, and also the layout of the power house, are shown by Figs. 7, 8 and 9, taken during progress of the work. Fig 10 is an interior view in the completed power plant, showing the generators in place.

The power equipment of the plant is direct-connected, consisting of General Electric revolving-field three-phase generators which are driven directly by Victor water wheels located in wheel chambers on the opposite side of the heavy northerly wall of the generator room. There are four generators of 1,500-kw. capacity and two exciter units, each individually driven from water wheels. The large generators operate at 133 r.p.m. and deliver current at 13,200 volts, for the control of which there is the usual equipment of instruments, oil switches and a handsome switchboard. For the transmission line, which is about 16 miles in length, aluminum conductors have been used, carried upon poles spaced about 110 ft. apart The latter carry also a telephone line on special cross-arms about 8½ ft. below the high-tension line.

The floor wheel chamber, where the turbines are located is about 13 ft. below the crest of the dam and from this level are suspended draft tubes from the turbines, which discharge into openings under the generator room leading to the tail race. Fig. 7 is a view from the upstream side showing the draft tube pits before the wheel chamber floor was in place, and the discharge passages leading to the race below. Fig. 8 is a view from the downstream side looking into these discharge passages. Fig. 9 is a view from the side of the structure in which a clearer idea may be obtained of the relative positions of the water wheels and the generators. Between the wheel chambers and the forebay is a heavy concrete wall carried well above flood load to protect the generator room and in this wall are placed the head gates. This wall also carries the timber frame work against which rest the rack bars that prevent floating matter from reaching the wheels. During freshets the river carries large amounts of driftwood and other material with which the forebay would become clogged in a few hours, and to prevent this a trash fender of pile and timber construction was placed in a proper position to intercept this drift and deflect it over the crest of the dam. The illustration at the head of the article shows the head gates, rack bars and trash fender in a general view from above the dam.

Contractor's Plant.—Having given an idea of the magnitude of the work involved next will be outlined the plant used in its construction which, when the writer took charge in Dec., 1903, was already installed and had been in operation several months. At the outset it is well to call attention to the sudden and severe freshets to which this river, and indeed most Southern rivers are subject, in order that the reader may have a clearer idea of the risks and dangers attending this class of work. Although the dry weather flow of Broad River is but 1,500 sec. ft., during freshets the stream becomes a raging torrent, passing enormous volumes and menacing all temporary structures in its path. A rise in river height of from 10 to 15 ft. is a common occurrence and at times much greater heights are reached. In June, 1903, occurred the most disastrous flood of which this district has any record, at which time Broad River at Neals Shoals came up about 30 ft. in 8 hours. On Pacolet River, a tributary of Broad, the flood was more severe and a rise of over 50 ft. was reported, several mills, with their dams being washed away and many lives lost. In the light of the above it is apparent that a plant for such work must not only be capable of efficient operation, but any portions which are in or near the river must either be secure enough to withstand these freshets or else be removed in advance of the flood; both methods are bound to cause much trouble and expense.

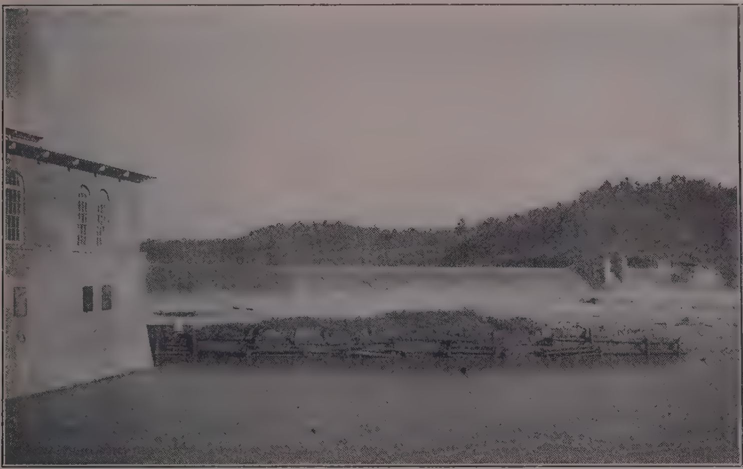


Fig. 2. Complete Dam with Overflowing Water

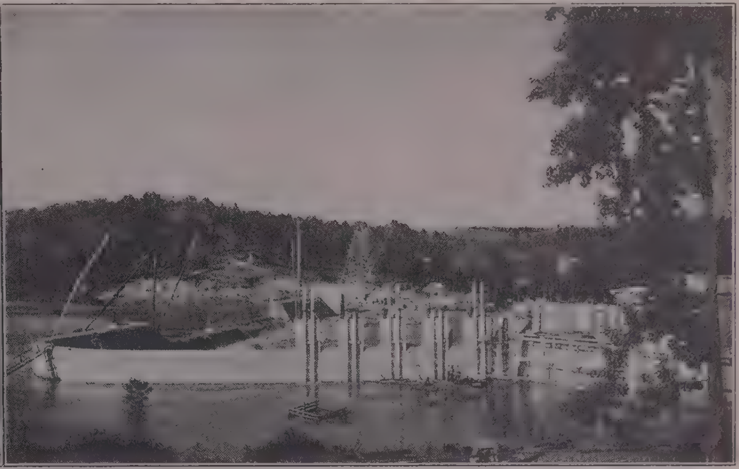


Fig. 3. View During Freshet, July 2, 1905.

Fig. 1 is a general plan of the contractor's plant at Neals Shoals which consisted of two parts; stationary and portable. The stationary portion includes the quarry, cableway, machine and blacksmith shops, main boilers, river pump for boiler supply and stone crushing and concrete mixing plant. These are units which can usually be placed where they may remain throughout the entire work or else subject to but slight modifications. The rest of the plant was portable, including derricks, pumps, isolated engines and boilers and steam drills, which were moved about as the interests of the work demanded. In view of the fact that the arrangement of this plant was directed by a contractor of wide and successful experience it is interesting to note its details and in a general way its efficiency for the work in hand.

It will be seen from Fig. 1, that the dam runs straight from its easterly end, nearly to the west bank of the river, then turns and runs parallel with the river to the power house, which structure is some 200 ft. below the main line of the dam. A cableway of about 1,150 ft. span was placed on line with the upstream side of the main dam, completely spanning the river and having its towers far above the reach of floods. As there was a large amount of rock in the power house and tail race excavation and nearly 6,000 cu. yds. of concrete to be placed in the power house, it was decided to put the stone crushing and concrete mixing plant just west of the power house and near a derrick so placed that it could feed the crusher, reach the discharge of the mixer and also control a portion of the excavations. The rock excavations beyond the range of this derrick were handled to it by others which also received and placed concrete in those portions of the power house beyond the reach of the crusher derrick. The derricks about the power hous were used in setting the steel beams, roof trusses and other heavy structural material.

For transporting mortar and concrete to the dam, tracks were laid from the mixer slightly up grade to within reach of the cableway. The concrete buckets were placed upon cars on these tracks and pushed under the mixer discharge. A mule hauled the full buckets to the cableway and the slight incline allowed the empty ones to return alone. Early examinations disclosed the fact that the most suitable quarry for the work was at a granite outcrop on the easterly side of the river and about 300 ft. above the dam. An opening was made here and tracks laid slightly down grade to the cableway. The quarried stone was placed on cars on these tracks by the derrick and two men pushed the cars to within reach of the cableway which landed the stone under the derrick, by which the masonry was laid. The men could also push the cars back to the quarry as the grade was slight. When the excavations in power house and tail race were completed the quarry had to furnish stone for the crusher and this stone was run on the quarry tracks to the cableway which set the loaded skips across the river to cars on the tracks leading to the mixer, where the derrick previously mentioned dumped them on the crusher platform. When masonry was in progress on the dam the cableway was so occupied in supplying mortar and concrete that it could not keep the masons supplied with stone; this being especially so when it became necessary to supply the crusher from the quarry in addition to other work. This made it necessary to operate the cableway at night, when enough stones were landed under the masonry derricks to answer the requirements for the next day. This almost constant work of the cableway subjected it to great wear and many stoppages for repairs were necessary which greatly delayed the work, the progress of which was largely regulated by the amount of material the cable could deliver. Another source of expense caused by the necessity of working nights, was the inability to land the quarried stone immediately upon cars and transport them to the work; for the stone quarried in the daytime had to be piled under the derrick and rehandled to the cars at night. Although the cableway was of great assistance in moving plant out of the path of floods and in transporting men and material across the river during freshets, I believe much better progress would have been made had locomotives and cars been used in its place. By this method cribs well-filled with stone would be so placed across the river that they could be incorporated in the downstream side of future cofferdams. From the corners of these cribs posts would rise to support the tracks well above any ordinary flood. Double tracks with suitable cross-overs should be laid on these posts and run under the quarry derricks. The derricks in the cofferdams should be set to command these tracks; by keeping a string of empty cars in the quarry all the time the stone could be landed on the cars as soon as quarried; the loaded trains would be placed under the cofferdam derricks and the stone set in the masonry with the least possible handling. Had the crushing and mixing plant been moved to the quarry when the rock in tail race and power house became exhausted, I think an improvement would have been made, for although there was still considerable concrete to be placed in the power house, this could have been transported from the quarry as cheaply as the spalls were and two handlings of the spalls would have been saved; viz., the rehandling on cars at the quarry and the handling to the crusher. The placing of the mixing plant at the quarry would necessitate the handling of the cement across the river, for all supplies come in on the westerly side, but this expense would have been slight compared with that of bringing the spalls over the river, handling them to the crusher and then taking the concrete back to the dam. Had cars been used, as above suggested, the mixing plant could have been placed to discharge into them and the concrete placed immediately under the masonry derricks.

The reader will ask how could a track be maintained in a river subject to disastrous floods? My answer is to make the cribs amply large and fill them with heavy stone; and to design the track span of such dimension that the restriction of flow will be reduced to a minimum; under the best of conditions the track will be subject to some damage, but the writer's observations lead him to believe that the advantages to be gained from such an arrangement will far outweigh any cost of repairs to the structure.

Derricks and Engines.—All of our derrick engines were of standard make and pattern of about 16 h.-p. and fitted with swinging gears. The derricks had masts from 65 to 82 ft. in length and booms between 60 and 78 ft. At the start all derricks were fitted with bull wheels, operated by the swinging gears, which made an excellent arrangement for excavations and other operation where great steadiness of boom is not required; but when the masonry was started it was found that much time was lost by the inability of the engineer to fully control the boom in the setting of large stone. A change was made to tag lines operated over the winch heads and this method being more positive in its action, accomplished better results. Although fully aware that a contrary opinion is held by some contractors of large experience the writer is fully convinced after two years' careful study of the problem, that engines for this class of work should be much larger than 16 h.-p. and would recommend at least 25 and in most cases 30. The derricks mentioned above are no larger than required for the work, and in most cases it would be advantageous to increase them somewhat; but they are too large for economical operation by engines of 16 h.-p., especially when the swinging gears are used. In consequence the engine is constantly overloaded, resulting in wearing of the parts and breakdowns; the derrick moves slowly, causing loss of time, and the size of stone handled is restricted to not over two yards. Another source of annoyance and loss is the inefficiency of a majority of the enginemen which the South affords and the certainty that their improper handling will result in unduly straining the machine, which is already overloaded. With the larger engine there will be considerable reserve power; it will never be overloaded; the derricks will move easily and quickly; the size of stone handled can be more than doubled, thus increasing the rate of progress and decreasing the cost of quarrying, and the large machine with reserve power is not as susceptible to the skill of the operator as the smaller and overloaded one. The only objections that the writer has heard to the use of the large machine are, first, it is more expensive to transport and move about on the work; second, in handling the larger stone which it is capable of, the masons will all stop work and keep from under the boom until the stone is placed, thereby causing much loss of time. With regard to the first objection I will say that the additional expense of handling the larger machine is slight and of no consequence when compared with the advantages it affords. My opinion on the second objection is that the tendency of a mason to "stand from under" is not due so much to the size of the stone as to the confidence the man has in the ability of the entire rig to stand the additional strain. Most masons would as soon be struck with a large stone as a small one, the result to them being the same, and it is my judgment that having once convinced your men that your rigging can handle safely the larger stone the losses of time due to this instinct of self-preservation will be no more, at least, with the large machine than with the small one.

Main Steam Plant.—This plant, consisting of two 60-h.-p. boilers of the locomotive type, was installed on the hill just west of the power house. It supplied steam for two derrick engines; crusher engine; mixer; pumps in tail race and power house excavations; the river pump for boiler and mixer supply; one pump in the cofferdams and the steam drills used in the foundations. The cableway, quarry derrick, and three other derricks used for excavations and masonry had their own boilers as they were beyond the reach and capacity of the main plant. The boilers were under a rough board shack, and had they been bricked in, an expense which I think the magnitude of the work justified, considerable saving in fuel would have resulted, especially in the winter weather. The leading lines from the boilers were of various lengths from 50 ft. to several hundred laid generally on or above the surface and immediately subject to changes in temperature. The expansion and contraction of these lines made it practically impossible to keep the joints tight and the losses due to leakage were considerable. The losses from radiation were also large and taken altogether the work done by this plant was entirely out of proportion to the power generated. One of the most difficult problems which confronts a contractor in planting a work of this kind is the character of the power plant. Formerly it consisted of a choice between a central steam plant with long leading lines, a number of individual parts or a combination of these two methods. The recent applications of electricity and compressed air to contracting methods give a wider field to choose from and investigation might show that for large work a producer gas plant could be employed to advantage.

The writer believes that an investigation of the relative applicability of all of these methods to the work in hand before reaching a decision would be time well spent. The boilers were all supplied with river water which carried a large amount of sediment, this being especially the case during and immediately after freshets, necessitating frequent washings of the boilers aggregating considerable expense. I think that the money so spent would be more than enough to provide driven wells, should the investigation show this source to be free from lime, to supply clear water for this purpose and would also remove the danger of "mud burns."

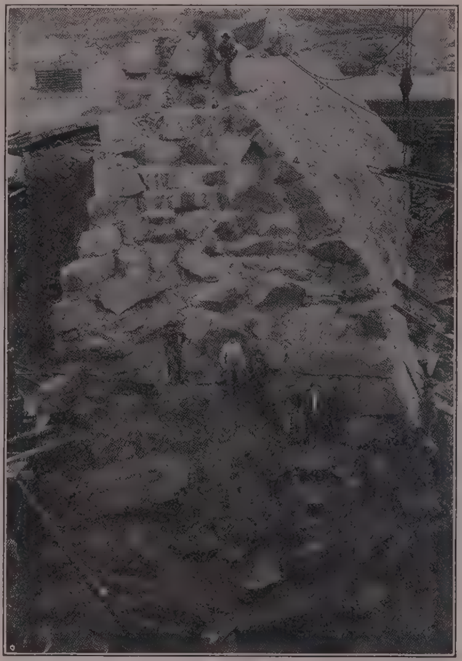


Fig. 5. Section of Dam.

Pumping Plant.—Having fixed the general outline of a plant for river work and determined the character of power to be used the next thing in importance is the pumping department. The cofferdams are usually of large area and likely to be of considerable depth so large volumes of water will need to be handled quickly to free a newly constructed dam or relieve one after a freshet—this is especially the case if the foundations are deep and the flood comes when everything is ready for the masonry. New cofferdams are almost sure to have some leaks and a freshet is likely to break through the old ones in places, therefore the pumps should be large enough to so lower the water level even with considerable leakage that the source and character of the leak may be definitely determined. Generally when the exact position of a hole is known it is a simple matter to devise some means of stopping it, but if your pumps are not sufficiently powerful to disclose the leak to view much valuable time may be wasted in finding it. On the work under discussion, the heaviest pump was a 6-in. centrifugal and after the dams were free of water the leakage was taken care of by 4-in. plunger pumps. Oftentimes the 6-in. pumps were not strong enough to develop the leak and vexatious delays resulted. I have heard men say that if a 6-in. pump would not free a dam improper work had been done, but I have seen a number of dams which were very tight except for a leak at one point that was easily stopped when found and yet this leak would more than hold a 6-in. pump. These dams afterwards proved to be of excellent construction. Although it may appear very large on first thought, I believe that one 12-in. centrifugal pump for this class of work will pay for itself many times before the contract is completed, and if the pump is of a type designed to handle sand and gravel much of the flood deposit can be removed in this manner. The 4-in. pumps provided for handling the ordinary leakage after the dam had been freed of water proved to be rather small for the purpose, it being necessary to run them at such high rates of speed that they frequently broke down and caused flooding of the work. The best 6-in. pumps that can be bought should be used for this service, for such a machine will handle the ordinary leakage of a properly constructed cofferdam without over loading. A small additional outlay for pumps, perhaps a trifle larger than actually required will prove a profitable investment in the end.

Comparison with Other Plants.—The modification suggested in the plant in general are those that impressed me as the work progressed. Of course, no man can tell absolutely at the beginning of a piece of heavy work just what methods he should use and whatever scheme is adopted will be subject to more or less unfavorable criticism and perhaps changes before the work is completed. I believe that the Neals Shoals plant will not suffer by comparison with any plant previously installed in the South, but I also believe that it can be improved upon and that my suggestions are in that line.

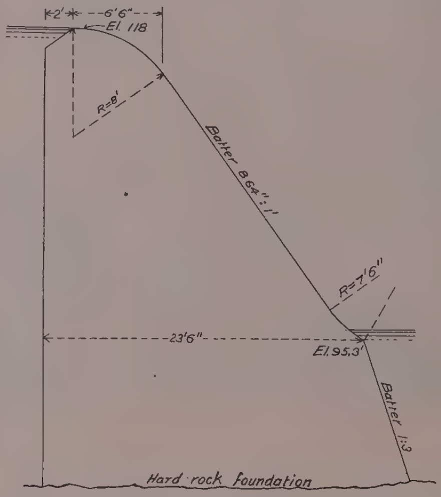


Fig. 4. Section of Dam.

Cofferdams.—While the details of the cofferdams used in the South, vary to meet the conditions encountered, their general type is the same: that is the anchorages consist of timber cribs filled with stone of various sizes. The spacing size and height of these cribs will depend upon the original depths of water and the stage of the work. When the first cofferdams are placed the restriction of flow will be slight with less liability to flooding, so a comparatively small, low crib may be used with fairly wide spacing. As the work progresses the completed structure will result in a continual deepening of the water above the dam and the cribs must be made larger, higher and placed nearer together. Square cribs are sometimes used, but a rectangular one with its longer side set with the current is more stable and will give decidedly better results. The cribs are usually constructed of logs held together at the corners by 1-in. iron rods which pass through inch and one-eighth holes bored in each end of the logs. Squared timber is sometimes used but it is more expensive and as the logs give as good results and can usually be obtained within a short distance of the work they are in more general use. Oftentimes the crib is built in the water on the position it is to occupy, but this is an expensive method and restricts operations to seasons when the men can work in water without being chilled. A better method is to place a derrick on a crib in such a position that it will control all sides of the cofferdam and build the cribs on a platform under the derrick, which then swings the cribs into position and guys up river will hold them until sufficient stone is placed to allow the removal of the guys. On the work herein described the cribs for the earlier cofferdams were built in the water, but later ones were constructed on shore under the cableway which placed them within reach of the cofferdam derrick and they were then put in position by the above method. The earlier dams were constructed in about five feet of water, the cribs were 8 ft. square, projected some two feet above the surface and were spaced about 15 ft. apart. As the work progressed the dimension of the cribs and depth of water constantly increased until in the final closure dam where we had a depth of 22 ft., the cribs were 10 ft. x 20 ft., with the long sides set in the direction of the current and placed in contact with each other. The cribs in this dam extended about 3 ft. above the normal water surface and were completely filled with very large stone, the voids containing smaller stone to make the mass as compact as possible. When the masonry was above the water level the cribs were unloaded and the stone used in the work. This method of using the crib stone for masonry was followed whenever practical. One very good and safe rule to follow in the design of cribs is to make the length of the side set with the current equal to the depth of water against which it is to act; where cribs are liable to be attacked by falling water during freshets it is wise to floor them over to prevent the stone from washing out. The next step in the construction of the dam is to place vertical posts at the corners of the cribs adjoining the water pressure. These posts should be bolted to the cribs by at least two ¾-in. wrought iron bolts with nuts and washers; drift bolts should not be used. We are now ready to proceed with the construction of that portion of the dam upon which its imperviousness depends and this generally consists of one of the three following types that will be described in detail. The so-called "tumbling dam," in which plank, resting on a waling piece placed upon the vertical posts, are driven with a dip upstream of about 35° from the horizontal; the clay chamber dam consisting of two parallel lines of plank spiked to waling pieces held to the crib posts by wrought iron rods, the space between the lines of plank being filled with clay; a single line of plank spiked to waling pieces on the posts and protected by a heavy bank of clay on its outer side. To build the first or tumbling type the crib posts are cut off at a uniform grade and to their tops is bolted a waling timber not less than 10 in. in diameter; at each post other 10-in. timbers lead upstream from the bottom of this waling piece at the angle of dip selected for the dam; these timbers should be well driven into the bottom and attached to the crib posts by ¾-in. bolts fitted with nuts and washers. Whenever practical a mudsill is placed upon which the upstream ends of these timbers rest. It is good practice to run these inclined timbers well by the crib posts instead of stopping them there, in which case the upper ends are supported by struts from the crib tops. This allows the sheeting to extend well over the cribs and protect them from disintegration during freshets. Other waling pieces are now placed upon these inclined timbers, parallel to the face of the dam and adzed down if necessary until their top surfaces are in line with the top waling, thus furnishing a uniform bearing for the plank. The plank are now laid on the waling pieces and driven as far as possible into the bottom, being redriven several times until further penetration is impossible. The plank are then spiked to each waling and cut off flush with the top one. Some of the spiking has to be done under water and for this work the following device, called by us "a gun" was used. A piece of 1-in. pipe sufficiently long to reach the lowest spike and still have its upper end out of water had an iron rammer, about 6-in. longer than the pipe, to work inside of it. The lower end of the pipe was placed under water at the point where the spike was to be driven, a spike was dropped down the pipe and the rammer used to drive it home. After the plank are in place a heavy blanket of clay is put upon them and carried well above the water level; this clay covering must be especially thick at the toe of the dam. This type is only applicable to the upstream side of a cofferdam where with shallow water and a river bed into which the plank can be well driven, it will give fairly good results; but unfortunately these conditions rarely obtain as most river beds contain numerous obstructions which either prevent the plank from penetrating or cause them to drive out of line, leaving openings which it is hard to close. Again the weakest part of this dam is at the toe which has to withstand the greatest pressure and this portion must be constructed under water, preventing the best of work from being done. As a result such dams are liable to blow out at this weak point, especially during freshets. In one of our earlier cofferdams this style was used on the upstream side as shown in Fig. 5 and it was also used in one other case. But its behavior was unsatisfactory and it was discarded in subsequent work. With the clay chamber type a pair of waling pieces, their horizontal spacing depending upon the thickness of the clay chamber, is bolted to the crib posts about 2 ft. from the bottom; similar pairs of walings are placed above the first one, the vertical spacing being from 3 to 4 ft., the top set being about the level of the tops of the posts. Each pair of walings is held in place by wrought iron rods, fitted with nuts and washers, passing through both walings and the crib posts; the vertical spacing of the walings on the side farthest from the posts is preserved during construction by occasional plank spiked to each waling and with their ends resting on the bottom. These temporary supports for the walings should be spiked on the upstream or outer side in order to leave the inside free for the sheeting. After the walings are in the sheeting is placed on the inside of each and forced by repeated drivings as far as possible into the river bed. It is well to make the driving light at first so that the water may readily pass under the ends of the plank and scour out some of the material; by repeated drivings and scouring the plank may be forced to sufficient depth. The tops of the sheeting may extend two feet above the crib posts without danger but if this is exceeded it is a good precaution to brace the tops from the farther side of the cribs. Too much attention cannot be given to the plank driving for upon it depends in a large measure the tightness of the structure. After the planks are thoroughly driven they are securely spiked to each waling and then the chamber is filled with clay in thin layers thoroughly rammed. Better results can be obtained if gravel is mixed with the clay to the extent of 25 or 30 per cent., but oftentimes such material is hard to find. The tops of the plank should be cut off at a uniform grade and a two-inch waling spiked on each side;

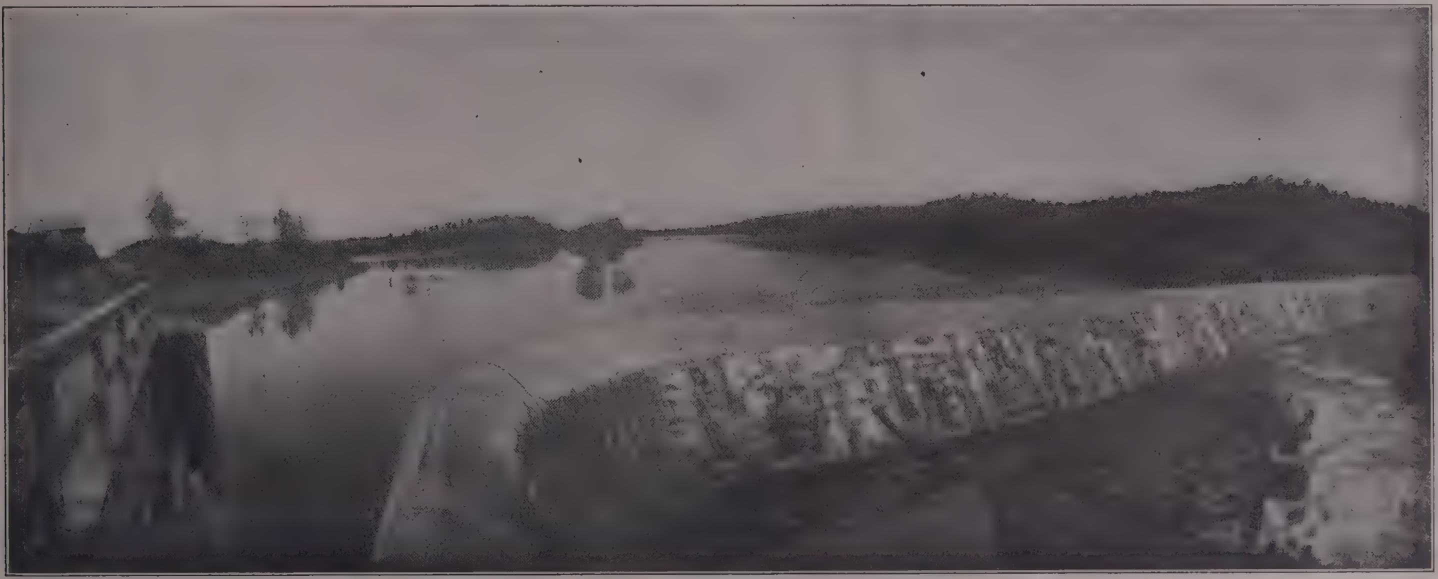


Fig. 6. General View of Neals Shoals Dam and Storage Basin, November, 1905.

this tends to keep the tops in line, and if crib braces are used as suggested their effect is more evenly distributed. After the filling has reached its ultimate settlement, the chamber is sometimes planked over to prevent scouring out during freshets. This is of great value on the portion of the dam which lies parallel to the current, but as it obscures the filling from view the plank should be removed occasionally and search made for local settlements. This kind of dam is the one in general use, it being considered the safest and surest method and is applicable to all ordinary conditions in moderate depths of water. It was used for the bulk of the cofferdams at Neals Shoals with clay chambers from 6 to 8 ft. thick and gave good results. The third type of dam was that used for the final closure where the water was over 20 ft. deep. A clay chamber structure was first considered but as the placing of the walings requires considerable under water work and the closure had to be made in the winter time it was necessary to adopt some method that would keep the men dry. The cribs for this dam as previously stated were 10x20 ft., set long way with the current, in contact with each other and compactly filled with stone. Posts extending from the bottom to two feet above the cribs were placed at the corners adjacent to the water pressure and horizontal walings bolted to these posts with a vertical spacing of about 3½ ft. To avoid under water work, soundings and measurements were taken so the posts and walings could be framed and bolted together on shore in suitable lengths and then handled into place by the cableway and derricks. As the cribs extended above the surface it was possible to bolt the posts and walings to each crib above the water at two points about 3 ft. apart, the water pressure being depended upon to hold the timber against the cribs below the surface. The sheeting was then driven by the methods described above and cut off even with the tops of the posts. A heavy filling of clay was deposited against the sheeting until the pumps could free the cofferdam sufficiently to allow the excavation to begin. The excavated material was dumped on top of the clay until the fill was some 3 ft. above the normal river height. This dam was quickly constructed, remarkably tight and withstood some seven or eight freshets without material damage. It proved an excellent cofferdam in every way and one that I should recommend for any similar conditions. After a cofferdam is completed it is well to allow it to stand several days before the pumps are started that the filling may compact itself before the pressure comes upon it. In all of the types described, before any filling is placed, it is well to make the structure as tight as possible by the use of strips of burlap forced around the bottoms of the plank and into any open joints by means of large poles. This will prevent, to a large degree, the material from washing through when the filling begins. Burlap is cheap and one cannot emphasize too strongly the wisdom of having plenty of it on hand for not only is it useful in the construction of the dams but there is nothing so efficacious in closing "blow outs," which may occur at any time. The writer has seen a dam made to stand a four-foot head of water before any clay was applied, merely by the use of burlap.

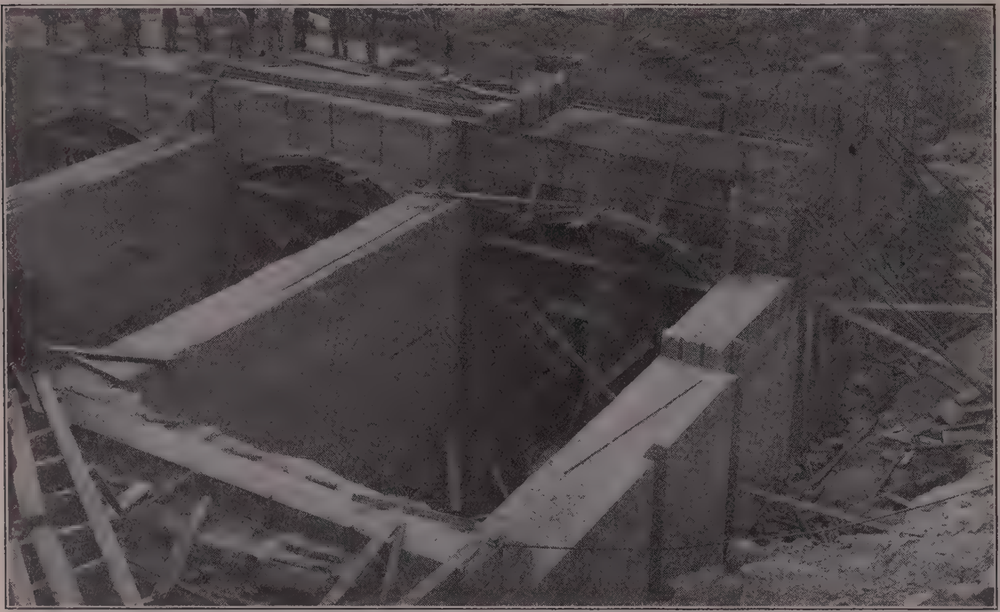


Fig. 7. Looking Downstream at Power House, April, 1904.

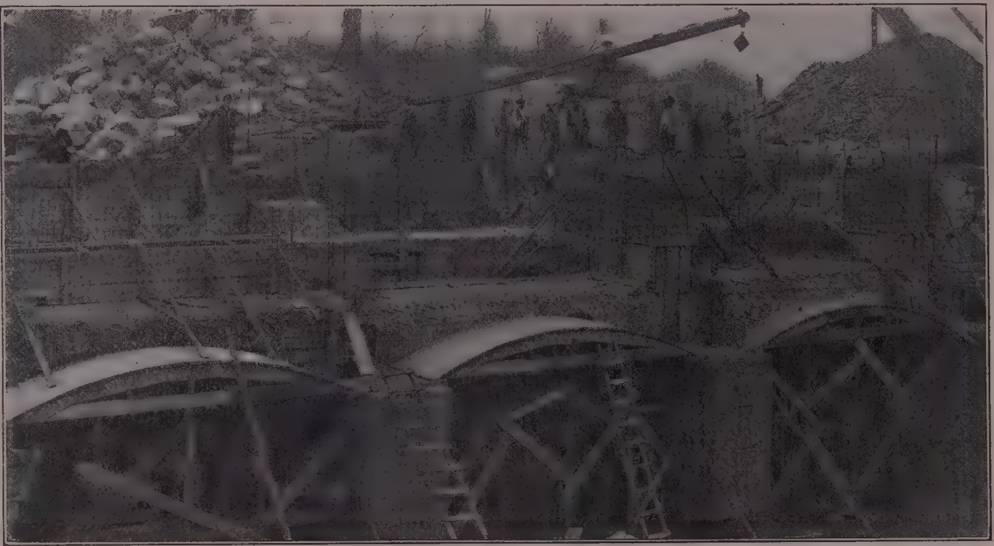


Fig. 8. Looking Upstream at Power House, April, 1904.

Depth of Excavation.—When the work was bid for it was supposed that the foundation for the dam was either at or very near the river bed. The rock outcropped at the easterly end and could be seen for some distance into the river from that shore; also at several isolated places on the line of the dam rock appeared to be at the bed of the stream. These surface indications led to the belief that the depth of excavation would be very slight although no borings were made to confirm it. As the work progressed it was found that with the exception of a short length adjoining the easterly shore, what had appeared to be solid rock was merely large, flat boulders about one foot thick and the suitable foundation was from 15 to 30 ft. below. Most of the excavated material, while not solid rock, had a rock structure and was very difficult to remove, entailing considerable additional expense, which was further increased by the cost of building higher and more elaborate cofferdams to withstand floods during the increased period of excavation and by the additional cost of pumping Altogether this work which was not anticipated when the contract was let increased the cost to the contractor to a great extent, but as the work was taken at unit prices it was ruled that no additional compensation could be had, as the contract did not stipulate or guarantee any particular depth. This being the case it behooves all contractors in taking work where no careful investigations of the foundation have been made, to make such examinations themselves. The cost of a few borings is slight when compared with that of building a light cofferdam with the expectation that the foundation is near the surface and finding later, to your sorrow, that it is far below and your temporary structures must either be strengthened or rebuilt.

General Requirements.—As stated earlier, most power plant work is somewhat removed from railroads and settled communities. The work under discussion was about five and one-half miles from the nearest station and nearly all of our supplies were hauled that distance. Near the close of the work a railroad was built in but it was too late to be of material advantage except in the transportation of the heavy machinery which it was impractical to haul by teams. This isolation renders it necessary to keep large quantities of supplies on hand as heavy rains make the roads nearly impassable and in the winter and early spring there may be long periods when hauling cannot be done. Proper arrangements must be made for storing a good supply of cement in tight buildings with the floors well above the surface of the ground. Extra care in the construction of these buildings will amply repay any additional expense so entailed. Preparation should be made for repairing plant and the machine shop should be equipped with a small lathe, pipe cutting and threading machine, drill press and an ample supply of dies, taps and drills of various sizes.

In the blacksmith shop modern appliances should be introduced and, if there is much rock work a steel sharpening machine will prove economical. Great care should be exercised in the selection of especially skilled men for work in these shops and there should be a thorough master mechanic who shall have personal supervision of all machinery connected with the work. A head rigger should be employed who will give his entire time and attention to the setting up, taking down and general inspection of the derricks and appurtenances. These men are usually hard to find and to secure them it is necessary to make the salary attractive. These skilled men and also the foremen will be white and comfortable arrangements must be made for housing and feeding them, otherwise they will become dissatisfied and leave the camp. Some of these men will want to bring their families with them and will ask that proper arrangements be made with this end in view. While one may be tempted to do this to secure the services of a specially skilled man, in the end it will be much better if no such concession is made. These camps are not places for women and children who should be left within reach of the protection, comforts and medical attention of some settled community. The shacks provided for the men should be supplied with comfortable beds and stoves and a laborer appointed to care for the rooms. A nominal rental, sufficient to cover this expense should be charged against each tenant and collected by the timekeeper on pay day. A commissary well supplied with goods must be maintained, when there are no local stores within easy reach. Another necessity is medical attendance; when the magnitude of the work demands it a resident physician may be employed, but in ordinary cases arrangements may be made with a local doctor who will be subject to call if needed and in addition make regular visits to the camp about three times a week. This expense should be covered by a small weekly charge against each man connected with the work, which will aggregate a fair fee for the physician.

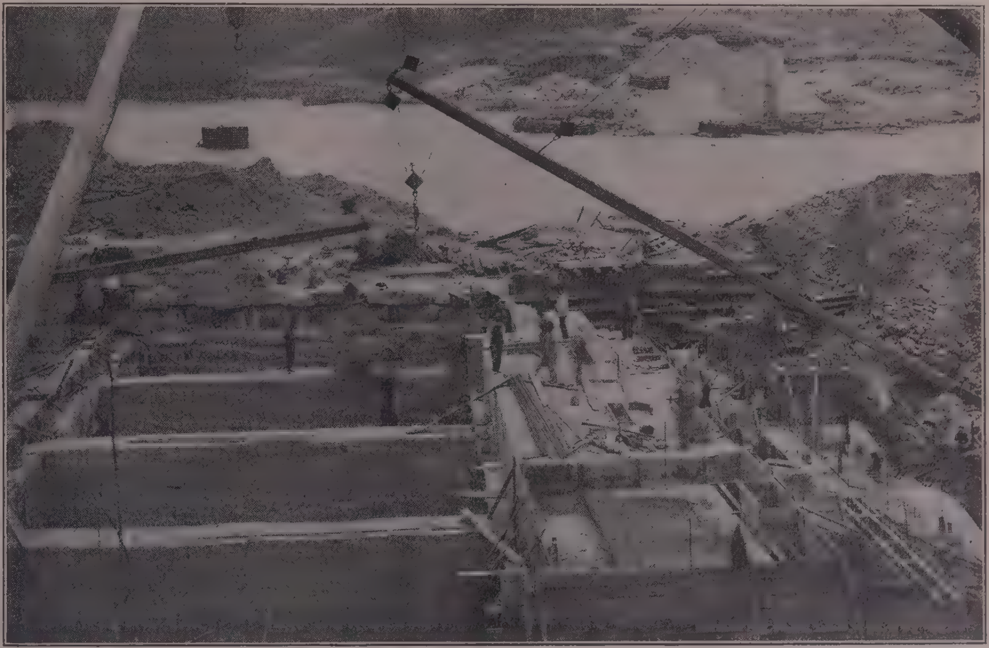


Fig. 9. Work on Reinforced Concrete Foundations of Power House.

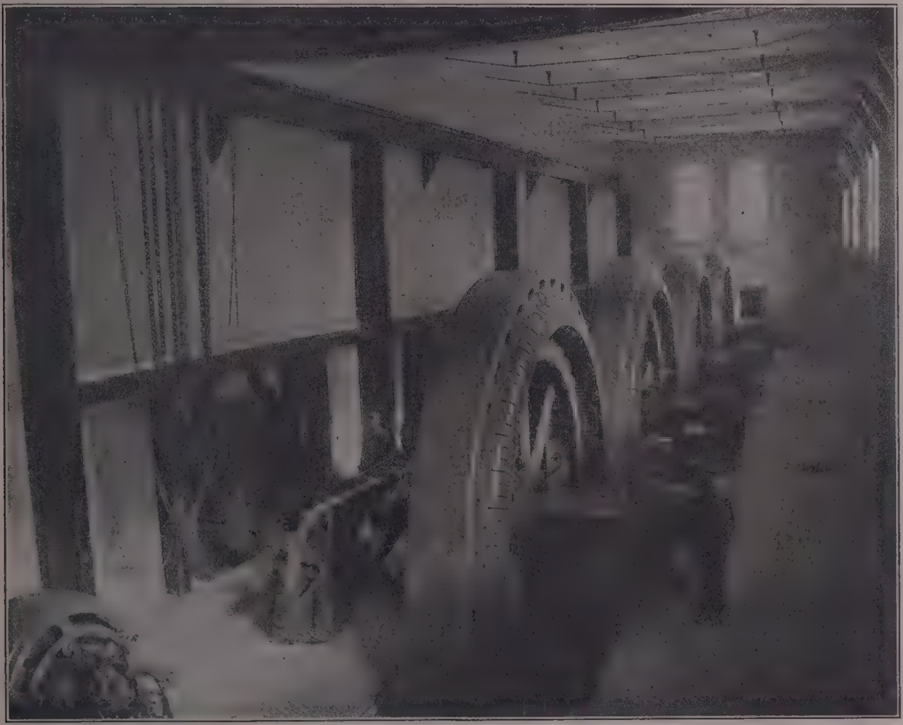


Fig. 10. Generator Room of Neals Shoals Power Plant.

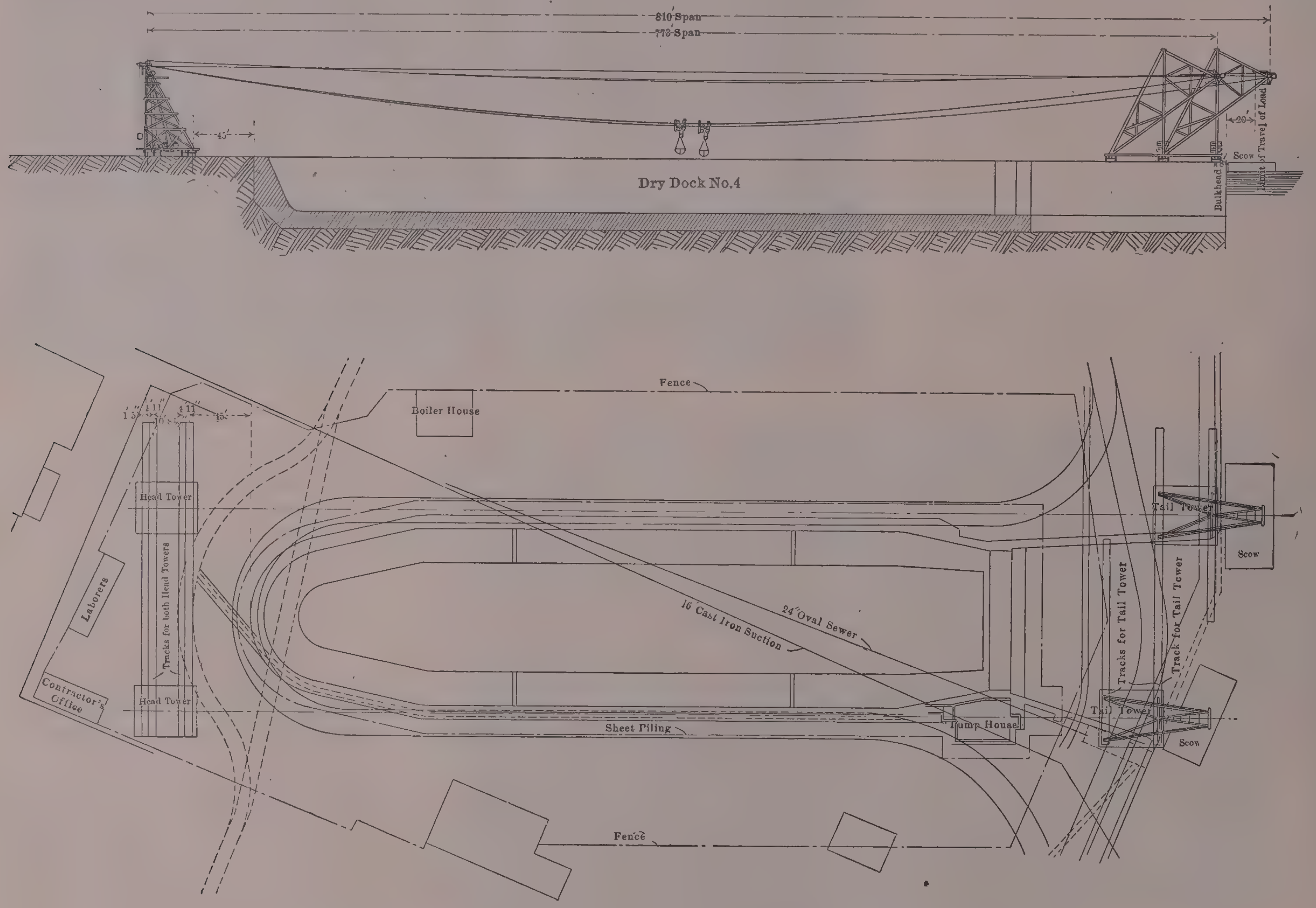
The work above described was completed in Dec., 1905. The engineers were W. B. Smith Whaley & Co., of Columbia, S. C., and Boston, Mass. Mr. G. E. Shaud, of Columbia, acted as chief engineer of the work The contractor was Mr. George O. Tenney, of Spartanburg, S. C. The writer was employed by Mr. Tenney as superintendent from Dec., 1903, until the completion of the contract.

The Labor Problem.—At the outset the contractor for work in the South will be confronted by a problem that will stay with him to the end and it will constantly be in front of him; it cannot be sent to the rear. There will be no labor unions to hamper him, for although these exist to some extent in the larger cities, in the outlying districts where most of the power plants are to be built their influence is not felt. But he will find a certain union fully as strong as the above against which all efforts to the present time have availed little. This is a union of the Negro against work. For if there is any one thing on which the colored man is a unit it is in the grim, continuous determination to perform no labor unless he is hungry and can steal nothing to eat. In preparing for a force of hands the first step is to build some substantial shacks with rough stone chimneys and open fire places in which cooking may be done, and have the men prepare their own meals. Have the shacks divided into rooms with accommodations for from six to eight and fitted with rough board bunks securely spiked to the walls. Do not supply mattresses or bedding, for such luxuries will soon disappear and any darkey who comes into camp with the intention of staying will make such arrangements for himself. Particular attention should be given to the roof and sides of the shack, that it shall be warm and dry. In the matter of floors one need no be so particular for the only use most negroes have for a floor is the opportunity it affords to hide whiskey under it; so if a high, dry place be selected for the camp no floor will be needed. It is well to have not over six rooms to each shack; have the rooms the full width of the building with a door at one side and a window in the other so placed that a clear view may be had of the interior from each opening. Furnish wooden shutters for the windows; no glass. The site of the camp sould be selected with due regard for sanitary advantages and reasonable regulations of this character should be enforced; a spring of fresh water should be near at hand; the camp should be well removed from the quarters for white men and yet near enough to the work to be constantly under the eye of the superintendent. As the work will probably be beyond the jurisdiction of any police organization, the contractor must be prepared to maintain order and discipline himself. The rules and regulations should be simple and few: such as will effectually safeguard the life, belongings, general comfort and health of the men and still not curtail their freedom to drink, gamble, attend hot suppers and engage in some minor settlements of differences of opinion as long as these diversions are conducted in a decorous manner. It is well to recognize at the start that you are not running a Sunday-school; that the Negro has habits and tastes to which he has become devotedly attached and if he is prohibited from practicing them he will immediately leave camp; so in passing judgment upon him he should be viewed through smoked glasses. Any serious offender should be immediately apprehended and turned over to the nearest law officer, but of all minor offences little notice should be taken. Once your camp has the reputation of being orderly and at the same time free and easy you will have little trouble in holding your men when there are any to be had. When the camps are ready for occupation agents should be sent out to collect the men. As labor is scarce, some Southern States have laws prohibiting the solicitation and transportation of labor outside the State. Many of the large cities and towns have ordinances of a similar nature restricting the movement of labor beyond their limits, even if it is to be used in their own State, unless a license fee is paid. The agent should be fully informed of all labor rules and regulations before starting out; be supplied with hand bills describing the location of the work, probable length of employment and wages paid; and sufficient money to transport any men he may collect. This transportation should be collected out of the future wages of the men. You will find it necessary to transport the women of some of the men and this transportation is also deducted from future wages. When an agent has a dozen or more men collected he should personally conduct them into camp and turn them over to the time-keeper. It is useless to give the men transportation and send them in alone for they will fall by the wayside for one reason or another and never reach their destination. Many of them start merely to satisfy their desire to ride in a train, intending to desert before the work is reached and oftentimes great tact and care must be exercised by the agent to get his charges safely landed. Upon arrival the time-keeper should assign them quarters for which a small weekly charge will be made; in some cases no shack rent is charged but I believe some collection should be made not only to cover the expense of the shacks but also as it tends to exclude from the camp the habitual loafers who lay around and induce some otherwise industrious ones to join them. Industrious is here used in its Negro sense. Most of the men will arrive broke and arrangements must be made to supply them rations until they have earned enough to take care of themselves. Experience shows that the negro works only enough to supply himself with the bare necessities of life, so he takes many holidays. As a result, it will be well to carry in your camps from 30 to 40 per cent. more men than the work actually demands in order to have at all times a working force. On the work the negro will prove about as efficient as any other class of labor; he is willing to do anything, go anywhere regardless of danger and is always in good humor. He should be directed by a white foreman who wholly understands the peculiarities and traits of the race in order to bring out the best there is in him. A few years since the wages of common labor in the South was 50 cents per day. This rate has steadily advanced until to-day many works are unable to obtain a sufficient amount at $1.25 per day. As a general rule, a raise in wages while the work is in progress does not induce the existing force to work any more time, but it does attract some outside men and thus the volume of your labor may be increased. Attempts have been made to introduce foreign labor but with indifferent success. In the cases that have come under my notice the two classes of labor were worked together and this method will probably never yield good results. Should a job be handled entirely by foreign labor, the camps designed to suit their tastes and the commissary stocked with the supplies such men are accustomed to a solution of this problem might be found.

Temporary Masonry Centers were used for putting in the arch of a short section of the Simplon tunnel where the pressure of the material above was too enormous for ordinary wooden timbering. It was found more convenient to put in the masonry centers than to try to set up equally strong steel centers in the very confined space available for the operation.

Excavation for Dry Dock No. 4, Brooklyn Navy Yard.

The three dry docks at the U. S. Navy Yard in Brooklyn, N. Y., are of different design and dimensions and have been built at different times. One of them is of timber construction, one originally of timber and later repaired and reinforced with concrete, and one of masonry. All are located in soft treacherous ground and all but the last named have given trouble in construction and in maintenance. The fourth dock which is now under construction will be slightly shorter and narrower than the largest one previously built there, but will be enough deeper so that its cubical contents will be larger than any of the others in the navy yard. It is to be entirely of concrete construction on a pile foundation. The inside dimensions will be about 542 x 130 ft. by 40 ft. deep and the length will be increased about 125 ft. by an extension beyond the caisson. The concrete will be of very massive construction and will have a maximum thickness of 11 ft. 9 in. on the bottom and about 17 ft. at the base of the side walls. It will be made 1:3:6 except for 2 ft. nearest the bottom where it will be 1:2:3, the interior surface being finished with 2 in. of granolithic concrete. An 18-ft. gauge track will be constructed around the sides and inner end of the dock for a 40-ton locomotive derrick. The inner rail of the track will be carried on the dock walls, the outer rail will be carried on a separate concrete wall 8 ft. deep and 3½ ft. wide at the base, supported by a double row of piles.

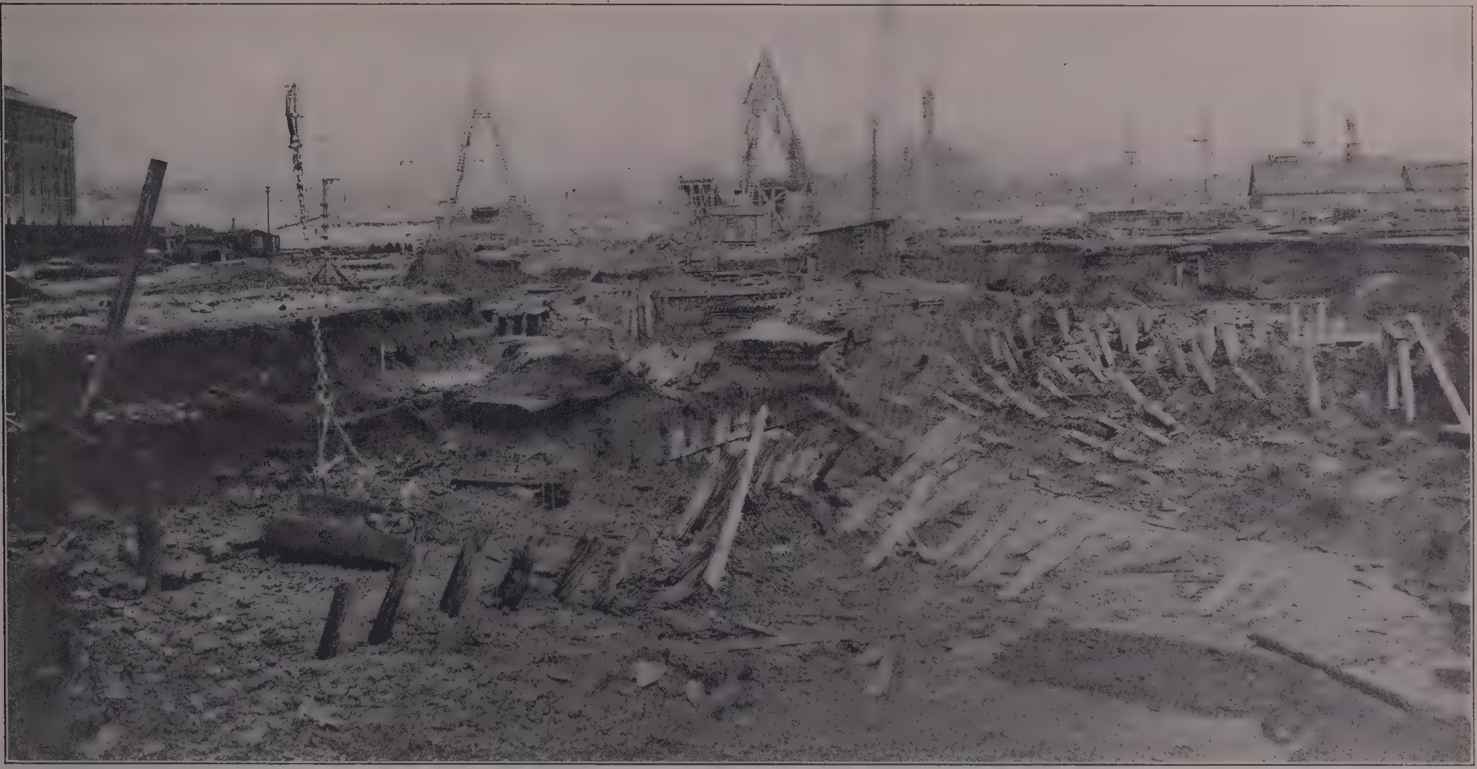


Arrangement of Cableway Plant for Building Dry Dock No. 4 in the Brooklyn Navy Yard.

The principal quantities involved in the construction of the dock include about 160,000 cu. yards of excavation, 9,000 bearing piles, 50,000 cu.

yards of concrete made with Alpha Portland cement and 175,000 ft. b. m. of best white oak timber for bilge and keel blocks, etc. The $757,800 contract for the construction of the dock was awarded on February 7, 1905, to Mr. G. B. Spearin, New York. Preliminary operations at this site were commenced February 22, 1905, and it is required that the work should be completed on August 7, 1908, thus allowing 42 calendar months for its execution.

It was recognized at the outset that the conditions for the construction were very difficult and preparations have been carefully made to provide for all the troubles, delays and obstructions that could be foreseen. A set of 13 test holes were jetted down to make a preliminary exploration of the soil in different parts of the site. Two or three of these encountered obstacles and were practically useless, the remainder of them were carried down to a depth of 80 or 90 ft. below the surface and from their general indications it was inferred that the average stratifications was 10 ft. of fill and miscellaneous substructures, 15 to 20 ft. of hard blue clay, 2 to 5 ft. of quicksand and below it alternating layers of different thicknesses of sharp sand and gravel of varying size. The depths of this strata below the surface of the ground are apparently very irregular, that of the quicksand varying from a minimum of about 20 to a maximum of 50 in a horizontal distance of about 300 ft.



View Showing Character of the Excavation for the New Dry Dock in the Brooklyn Navy Yard.

This site has been used for many years by the navy yard and successive structures have been built and removed there, leaving numerous wooden and masonry foundations buried in all parts of the site, many of them massive and large enough to very much impede the excavation. The quicksand was also known to be of especially troublesome character, as is illustrated by the fact that the excavation for dry dock No. 2, caused a deep subsidence of the surface over 50 ft. distant from the edge of the pit.

The contractor found the site occupied by two large two-story brick buildings with slate roofs and by several smaller corrugated iron buildings, a paved roadway and other obstructions.

According to the conditions of the contract he was required to enclose the site by a fence located, as shown on the plan by dotted lines at a distance of 90 ft. beyond each side of the finished dock and to restrict his operations entirely to the limits thus defined. He built the fence and removed the buildings enclosed by it, some of which included brick work 20 ft. thick horizontally. There was also crossing the site a 72-in. brick sewer belonging to the city system. A by-pass was therefore built for this around the shore end of the dock and supported on piles 40 ft. long driven to a refusal of 12 in. under the last 10 blows of the hammer, and cut off 12 ft. below the surface of the ground or about 7 ft. below mean high water.

It was also necessary to build a line of two 42-in. cast-iron mains for a condenser system in another part of the navy yard. For this purpose the first operation was the excavation of a trench 12 ft. wide and 20 ft. deep. This was sheeted in the usual manner with 4-in. tongue and groove sheet piles driven by hand. The bottom of the trench penetrated just below the upper surface of the stratum of quicksand, which caused much difficulty. The outside pressure bent in the thick sheeting below the bottom ranger and cross braces, which were only 3 ft. above their lower ends. A ditch was dug along each side of the trench close to the feet of the sheet piles and the water collected in them was pumped out of a 75-ft. length of trench by one 6-in. Cameron pump. This was sufficient to keep the water and quicksand down long enough for the foundation piles in the trench to be cut off at the required level, capped and decked with timber, and a concrete footing to be laid on the latter. This work was all done as rapidly as possible and after its completion no further trouble was experienced by the quicksand at this point.

Allowing a slope of ½ to 1, for the sides of the excavation for the dry dock itself, which will have a total depth of about 52 ft., it is seen that the space on each side of the dock inside the fence is at the best reduced to but little more than 60 ft., a portion of which must be kept unobstructed for transportation. Few engineers would, however, be willing to trust such steep banks in soil of this nature, and it is seen that the space allowed for contractors' operations is extremely limited and that the question of storage for the large quantities of materials required on the work became a very serious one. It has been solved by a decision to keep only about one-third of the total amount of cement required at the site and to store there only a comparatively small quantity of sand and stone, which will be reserved for emergencies, while the bulk of these materials will be delivered on scows at the water front opposite the dock and will be taken directly from them as used.

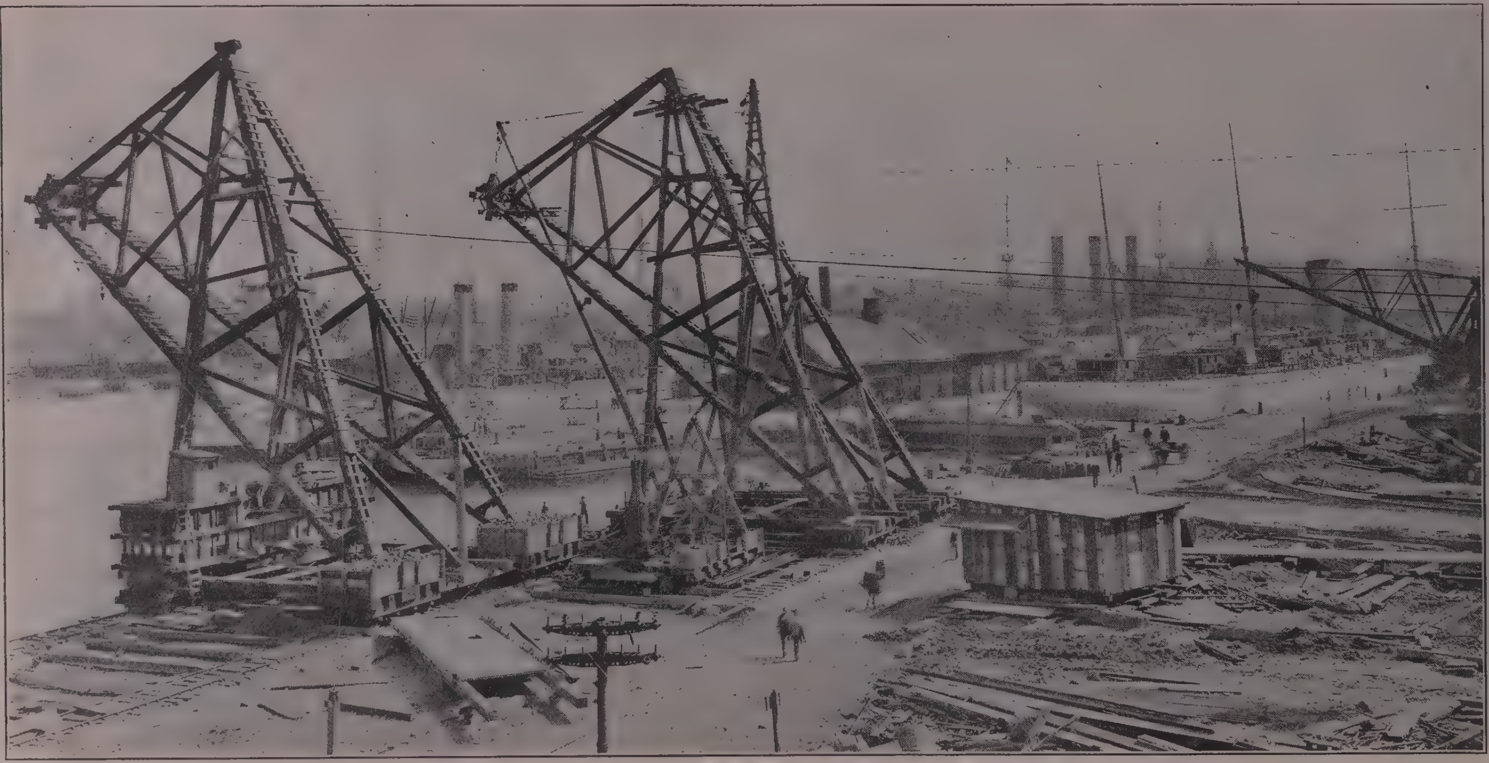
The limited area was considered inadequate to afford space for the tracks of an excavator plant traveling parallel with the axis of the dock. A novel arrangement was therefore devised and consists of a pair of special Lidgerwood traveling cableways of 773 ft. and 810 ft. spans with their tracks at right angles to the axis of the dry dock. Both of the head towers travel on the same track at the shore end of the dock and clear of it; they must therefore always remain in the same relative position and cannot pass each other, a condition which is not considered objectionable.

The tail towers have separate tracks as near as possible to the water front, between it and the entrance of the dock, and clear of the latter on the site of the dock entrance, which, by the requirements of the contract, must be left undisturbed until 90 per cent. of the dry dock is completed, when the contractor will be allowed to build there the entrance construction. This arrangement is made in order to provide for the maintenance, as long as possible, of the navy yard roadway along the water front. The tracks of the tail towers are arranged so that the river-side trucks of one tower run on the same rails as the in-shore trucks of the other tower, thus allowing the relative positions of the towers to be offset and enabling them to serve both angles of the water front. The line of the water front makes an obtuse angle opposite the site of the dry dock.

Each cableway is equipped with a Hayward two-yard orange-peel excavating bucket of extra heavy construction, which is operated entirely from the head tower. It descends to the bottom of the excavation, fills itself, rises and is traversed to the water front, dumped into a scow, and returns for another load without any attendance other than that of the operator at the engine. In order to provide for this service the tail towers are of special construction with a cantilever projecting over the water, through which the bucket passes to dump into a scow beyond the tower track.

Both cableways have been installed and in operation for several months and under extremely adverse conditions have each excavated 400 cu. yd. in 8 hrs. A large number of old foundations and other obstructions have been encountered in the pit, and have materially delayed the excavation, very greatly reducing the capacity of the cableways, among them are numerous stone and concrete walls and piers, piles, and two large bulkhead or pier cribs built of timber and filled with stone. Excavation is carried around these and they are generally lifted out piecemeal by the bucket or chained to the cableway hoisting block. The cableways are at present excavating parallel pits on opposite sides of a large section of the old crib work and as considerable water is encountered, two sumps have been established, one on each side of it, which are drained by centrifugal pumps operated by General Electric motors.

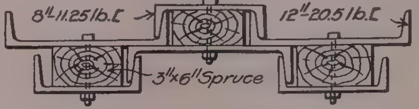
All of the excavation is to be made within sheet piling and careful consideration was given to the type adopted. Investigations were made and orders were successively placed with two firms for the supply of special types of steel sheet piles, but in both cases the orders were eventually cancelled on account of the inability of the manufacturers to furnish them, due to delay in receiving special shapes from the rolling mills. A new type of pile was finally devised by the resident engineer, Mr. Bassinger, expressly to meet the requirements of the case and so that it could be manufactured at the site from commercial shapes easily and quickly obtained.



Toil Towers Used for the Cableways at the New Dry Dock in the Brooklyn Navy Yard.

It is made as shown in the sketch with channel bars of different widths fastened together, making a joint which has at first a clearance of about ¼ in. and is considered to be satisfactorily water tight after the wood has been swelled by the ground water. These piles are assembled at the site from ordinary 8-in. 11¼-lb. channels, 3½ x 5-in. spruce timbers and 12-in. 20½-lb. channels in 50-ft. lengths secured together with single lines of ¾-in. bolts 12 in. apart. Two rows of piles on opposite sides of the dock are driven simultaneously their full length by two Vulcan steam hammers operating in ordinary pile-driver leads. It requires an average of about 25 minutes to drive one pile without the use of an hydraulic jet, but the latter has recently been provided and will probably expedite the driving.

Obstructions under the surface have in two instances caused the piles to deflect as much as 2 ft. from the vertical and this divergence has been easily corrected by driving the six succeeding piles with narrower filler strips and beveled points, which allow each one to form a small angle in the joint. Special piles are provided for corners of the coffer dam, which will be built in three successive sections, the piles being pulled and concrete placed as the excavation proceeds. Other special piles are also driven in the sides of the coffer dam at intervals of 25 ft. They are provided with connections at right angles so as to allow the construction of small enclosed coffer dams on the outside of the main coffer dam if it should become necessary to locate leaks and repair the coffer dam at any point without interfering with a considerable length of the piling.



Special Sheet Piling.

The cableways are duplicates except that the spans vary slightly in length. The main cable is a 2¼-in. patent locked steel rope with an ultimate strength of 212 tons. It is carried by a traveling-head tower of standard design running on two 3-rail tracks, and by a traveling overhanging tail tower of special design running on two standard gauge tracks 37½ ft. apart on centres. The tail tower is of special construction and essentially consists of a cantilever tower with an overhang of 37 ft. which projects beyond the wharf line and allows the bucket to travel through it and discharge to the dump scow. It is very strongly framed with heavy timbers and special steel tension and anchorage rods with sleeve-nut connections and screws or loop ends. The connections of the principal members are strongly made with steel gusset plates and through bolts.

At the apex of the tower the inclined posts are united by a U-plate, which receives the riveted connections of adjustable tension bars engaging the platform of the ballast box, which is counterweighted with 125 tons of stone. At the extremity of the cantilever there is a solid crosshead, built of heavy forgings and a horizontal beam made with a pair of 20-in. I-beams and cover plates enclosing a solid oak filler to which the end of the main cable is attached. Both longitudinal and transverse sills of the horizontal platform are trussed and the tower is mounted on four 4-wheel trucks.

It is so rigid that when it was accidentally rammed by the top masts of the U. S. despatch boat, "Dolphin," it broke them off, but was not itself broken or overturned. The cantilever was deflected laterally about 8 ft. and left with a permanent set of about 6 ft. It was not, however, found necessary to remove the distorted cantilever, and the members were straightened and the original main timbers were reinforced by packing the space between outer members, thus giving them a 14 by 36-in. solid cross-section.

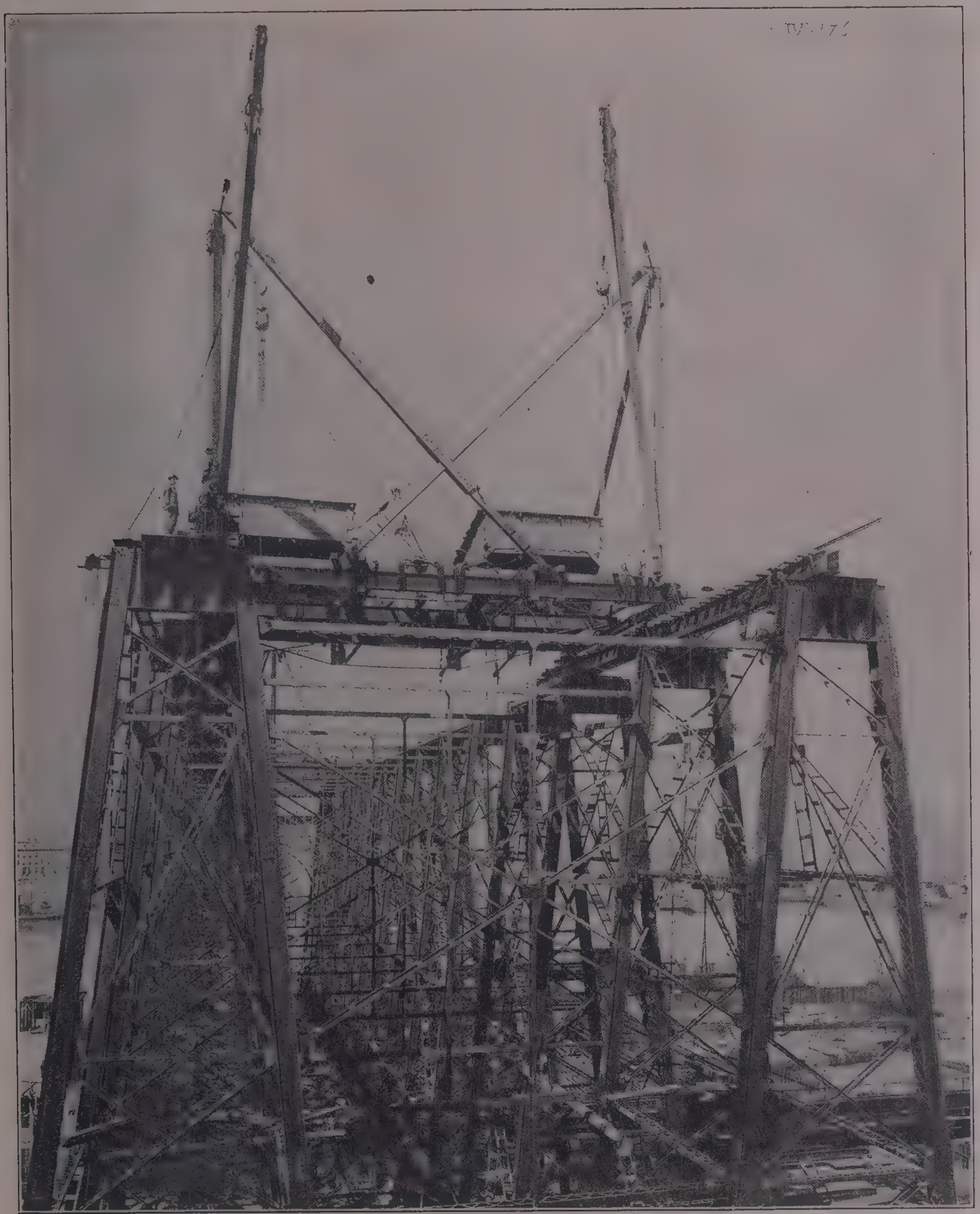
Each cableway is equipped with a Hayward 2-yard extra-heavy orange-peel excavating bucket, which weighs empty about 9,000 lb. and may carry a load weighing 7,000 lb. more. The cableway is equipped with a reversible engine having double cylinders of 14-in. diameter and 18-in. stroke. It has three tandem friction drums each 51 in. in diameter with a 60-in. face grooved for ⅞-in. plough steel operating lines, the ultimate strength of each of which is 34 tons. Each drum has a band brake and the levers are all assembled in a rack at the rear of the engine. The upper drum holds the conveying rope which pulls the carriage back and forth on the cable. This line is in two separate parts, which are fastened to opposite ends of the drum and are wound in opposite directions so as to wind on and off simultaneously. The other two drums hold ⅞-in. lines, one for closing and hoisting and the other for holding and opening the excavating bucket.

When the cableway was installed the tracks for the overhanging dock towers were laid over an area paved with Belgian blocks. It was evident that the enormous stresses from the cable would produce a strong tendency for transverse motion of the tracks on the pavement. To correct this a special system was devised to anchor these tracks into the pavement and distribute the stress throughout a large area of the latter. This was accomplished by removing ocasional paving stones or groups of stones and then building over these places continuous concrete walls about 2 ft. high and 4 ft. wide to receive and support the ties for the traveler track rails and distribute the load over the surface of the ground, the tie ends being embedded in concrete. In this manner the concrete was filled in the vacancies left by withdrawing the pavement blocks and thoroughly bonded or anchored the track to the pavement, a device which has proved very satisfactory. The cableway engines receive steam at 125 lb. pressure through pipes connected by swinging joints to a 6-in. delivery main from the power house on one side of the lot. The power house contains three 125-h.-p. locomotive firebox boilers made by the Erie City Iron Works.

The towers are moved by tackles anchored along the tracks with their lead lines operated by capstan heads on the tower engines; small hoisting engines being provided for this purpose on the tail towers.

It was feared that the impact of 2 yards of heavy material being dumped from the excavating buckets at a height of over 40 ft. might be injurious to the scows which receive it. Heavy inclined aprons or chutes a few feet above the level of the ground have therefore been provided to receive the falling materials, thus spreading them out in a thinner sheet for delivery with less shock to the scows. For one cableway this apron is mounted on an independent framework movable along the dock face with the cableway. For the other cableway the apron is supported on a timber bent that is normally blocked up on the edge of the wharf, but can be suspended from the overhanging tail tower clear of the ground and moved with the cableway. Besides the machinery already mentioned the principal plant installed to date includes twelve 1-yd. steel buckets, 3 Lidgerwood 3-yd. steel skips, 1 Hayward, 2-yd. clam shell bucket and 1 Ransome concrete mixer besides the ordinary miscellaneous plant and tools necessary for such work.

The work is being executed under the direction of Mr. R. C. Hollyday, chief engineer of the Dock Department in the Navy Yard. Mr. J. S. Bassinger is the engineer in charge for the contractor and the cableways were designed by Mr. Frank B. Knight, one of the engineers of the Lidgerwood Manufacturing Company, who built and installed them. The construction is one of the most difficult works in progress in New York.



Erection of Steel Falsework Towers, Island Span, Blackwell's Island Bridge.

Erection of the Upper Part of the Trusses of the Island Span of Blackwell's Island Bridge.

After the lower part of the island span of the Blackwell's Island bridge has been completely erected up to the center points of the vertical and diagonal posts the remainder of the steel, which comprises about 5,000,000 lb., exclusive of towers and is approximately 1/3 of the total weight o the span will be erected by a pair of Z-shape towers that will afterwards be used for the simultaneous erection of the cantilever arms of the channel spans. The lower part of the island span has already been nearly erected by the single No. 1 traveler already described which consists essentially of a horizontal platform and two stiff-leg boom derricks. The first No. 2 traveler has already been partly erected on the upper deck of the span between panel points 63 and 65, and the other traveler will be erected as soon as practicable between panel points 59 and 61.

These travelers were illustrated and described in The Engineering Record of March 18, 1905. Each consists substantially of a 36x40-ft. riveted steel tower 124 ft. high with trussed extended base 86 ft. long and an overhead forward truss extension of 63 ft. The base provides a rigid horizontal platform supported at each corner on 4-wheel and 6-wheel trucks traveling on standard gauge tracks 40½ ft. apart. The platform is counterweighted by hoisting engines, boilers and supplies in the rear which aggregate about 70 tons. When the traveler is in service its stability is increased by blocking under the cantilever ends of the transverse sills which thus extend the base to a total width of 54 ft. and by anchoring it to the completed steel work with four powerful sets of adjustable clamps.

The upper part of the traveler and the overhang are provided with transverse horizontal plate girders projecting 20 ft. each side of the tower to carry clear of the highest part of the permanent superstructure, several lines of longitudinal steel jigger beams from which will be suspended many tackles in the vertical plane of the trusses with capacities or from 5 to 40 tons each. They, together with auxiliary tackles suspended from inner lines of jigger beams and directly from the transverse girders will serve for direct handling of members of the truss and bracing systems. One of the 65-ton stiff-leg boom-derricks, like that previously described for the unloading service, will be mounted on top of the traveler to handle some of the heaviest members of the island and cantilever trusses.

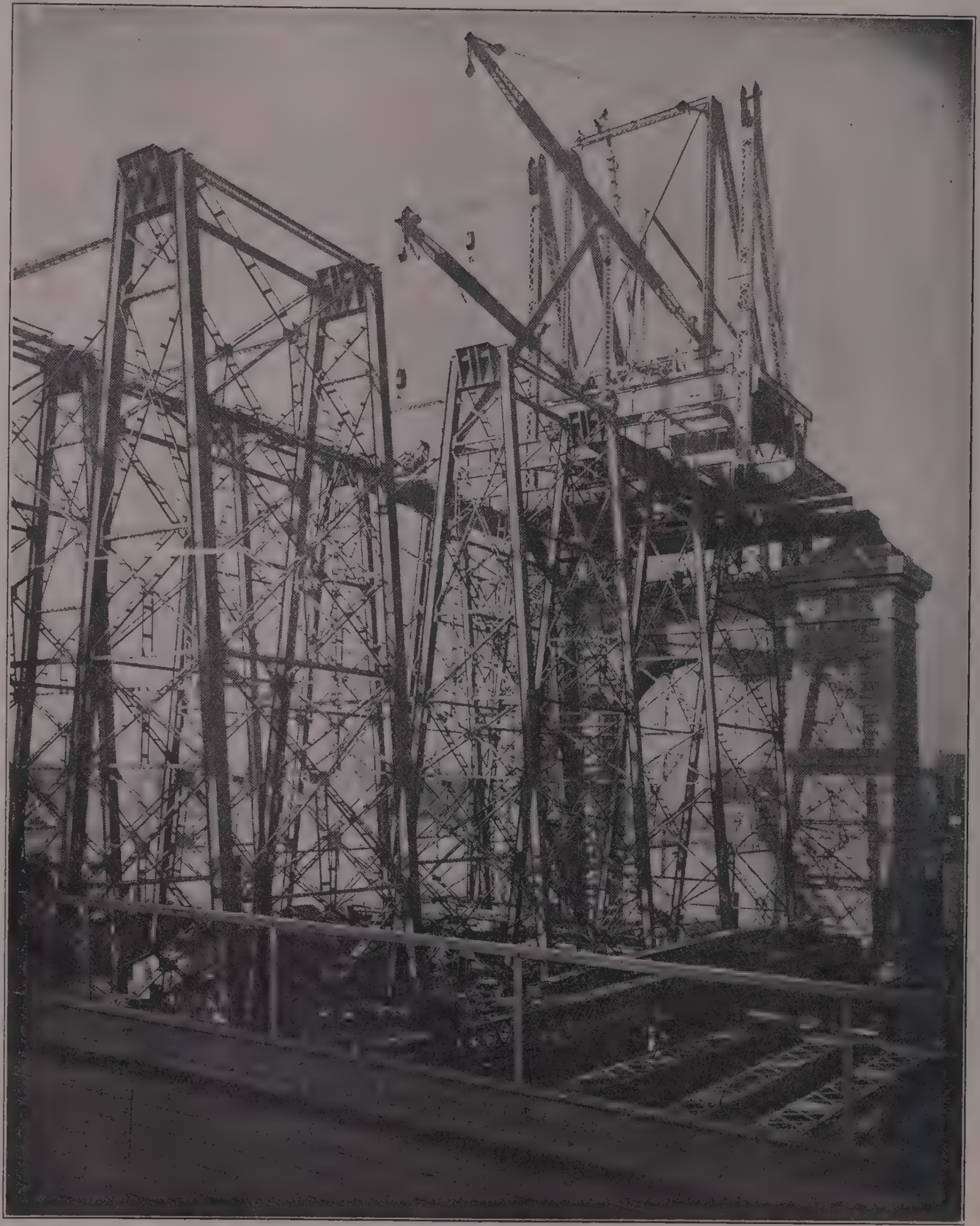
The traveler will weigh about 400 tons without its rigging and about 550 tons when full rigged and equipped with one special 6-spool hoisting engine and one standard 8-spool hoisting engine. It will require a force of about 60 men to operate it. The heaviest piece which it will be required to handle weighs about 80 tons. On the island span the traveler will assemble one main panel of the truss in each position and can be moved from one point to the next in about 2 hours.

Great care was taken in designing the traveler and in proportioning it for the heavy stresses, and for the eccentric loads, wind pressure and reactions involved by the very heavy members to be delivered. One of the most interesting features is the construction of the trucks. Those at the foot of the forward columns are quite elaborate and are practically double, being made as shown in illustration with two sets of longitudinal sills each having two pairs of double flange wheels. Each sill receives two pedestals, pin connected to shoes at the opposite ends of two transverse girders. The latter carried a massive framework receiving the base of the vertical post and providing for the equal distribution of its loads on each of the eight wheels supporting it. The trucks supported the rear end of the traveler platform although massive, are of such simpler construction and have four single-flange wheels each. The longitudinal sills in which these wheels are set are provided with rigid bolsters to which the transverse loading girders are web connected. The traveler was erected up to about the middle of the tower by means of two 60-ft. 10-ton derrick booms temporarily rigged to vertical posts in the main trusses which served as masts for them. The transverse trusses in the lower part of the traveler were assembled together complete on the surface of the ground and hoisted by the two booms together. The other members of the traveler were hoisted and assembled to them separately. The upper part of the traveler has not yet been completed, but it is intended to erect it by means of a stiff-leg derrick seated on the temporary platform built on the transverse struts at a height of about 60 ft. above the foot of the traveler. The additional derricks will be used for building out the overhanging trusses.

The lower chords of the island span are massive compression members about 7 ft. wide x 4 ft. deep made with four lines of heavy webs, and possess great rigidity and transverse strength. Their lower surface is in the same plane as the bottom flange of the floor beams to which they are rigidly connected. During erection they are supported on the tops of four riveted rectangular pedestals about 3 ft. high, symmetrically arranged about 2 ft. apart in the clear on the top of each falsework bent. The elevation of the chord is adjusted by means of steel shim plates inserted between the tops of the pedestals and the chord lower flange cover plate and may be varied to correspond with settlement of the falsework which was anticipated or to modify the camber and facilitate driving the truss pins. In order to do this, special girders about 8 ft. long and 15 in. deep can be set transversely under the chords between the pairs of pedestals and supported on pairs of hydraulic jacks. Eight 500-ton and six 250-ton hand-pump jacks have been provided and with them it will be easy to lift the chords sufficiently to enable the shims to be removed and others of different thicknesses substituted in their place.

It is intended to commence the erection of the upper parts of the trusses at the center of the span where materials will be hoisted from the storage yard by a special 65-ton boom derrick seated on the elevated floor and delivering to cars on material tracks on the cantilever brackets of the lower floor parallel with the axis of the bridge. These cars will take the members traveling outside the trusses to a point where they will be hoisted to position and assembled by the tackles suspended from the jigger beams. The travelers will move simultaneously in opposite directions and will finish the erection at piers II and III, where the last pieces to be erected will be the upper parts of towers at panel points 57 and 75.

These towers are over 185 ft. in extreme length and when erected they will be vertical, as is required in their ultimate position in the completed bridge. At the time of their erection the island span will be temporarily distorted on account of the lower chord being assembled with a reverse camber to provide for the stresses developed later in the erection of the cantilever arms. This condition will displace all of the members of the truss and will make it necessary to move the upper end of the tower about 7½ in. out of plumb towards the center of the span in order to have the pinholes in the tower and top chord bars match and enable pins U-57 and U-75 to be driven.



Erection of Steel Falsework Towers, Island Span, Blackwell's Island Bridge

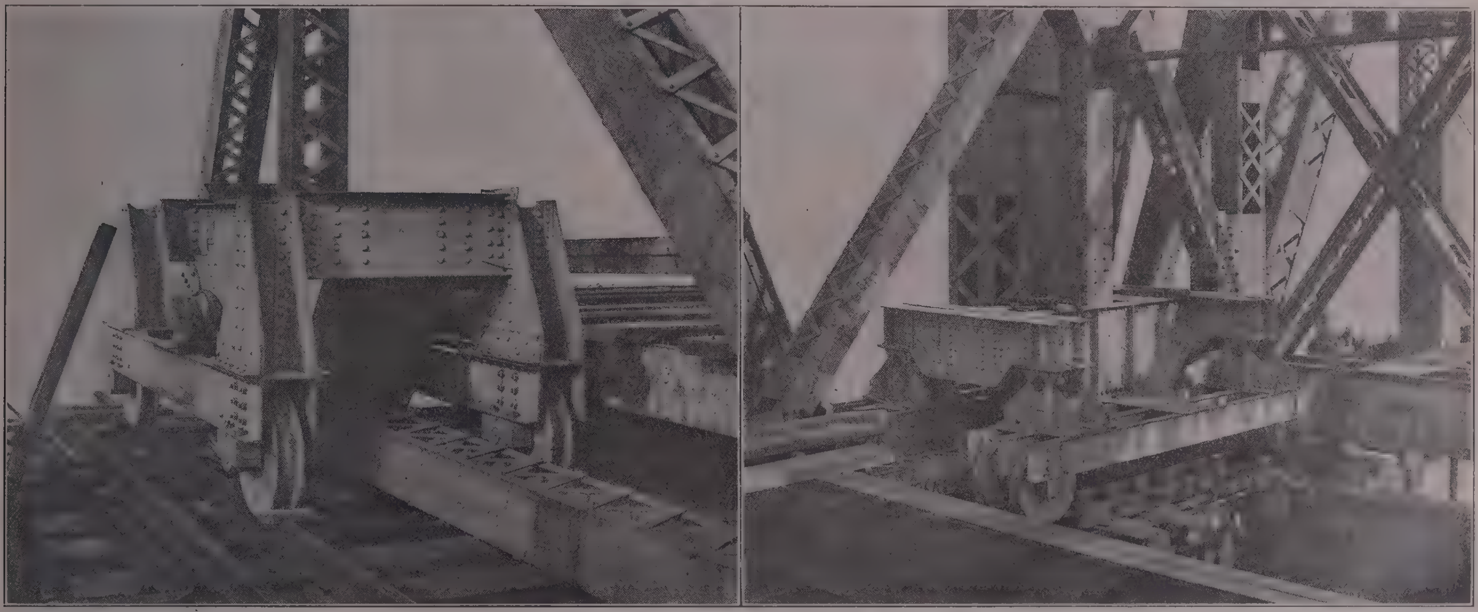
It is proposed to secure this temporary deflection of the tower by bending the upper portion, its great length making it possible to do this without a stress exceeding the elastic limit of the material. Powerful tackles will be attached to the upper end of the tower and the reaction will be provided by a special horizontal temporary strut reaching from C-57 at the middle of the post to C-58. This strut will be provided with pockets at one end in which a pair of 70-ton hydraulic jacks will be placed in a horizontal position and provide for adjustment and pressure requisite for any reaction. The post will thus be held firmly with powerful forces in opposite directions and will at all times be perfectly controlled.

The top chord pins, 16 in. in diameter and nearly 10 ft. long, will weigh as much as 6,500 lbs. each and will engage a maximum of about 40 eyebars besides the vertical and diagonal posts. As the clearance of only about 1/50 in. is allowed it will be very difficult to drive these heavy pins 200 or 300 ft. above the ground. A ram such as was recently described for the lower chord pins would be difficult to handle and would require special provision for its suspension and special platforms for its operation. It was, therefore, decided to provide new and special methods for making the top chord connections and the pins will be driven by pressure instead of by impact. A riveted framework will engage all of the members at the panel point, and is provided with means for clamping them strongly together. It will have integral with it horizontal trusses projecting towards the center of the bridge which will carry a 100-ton hydraulic jack with a horizontal plunger operated by a pump driven by pneumatic pressure. The whole apparatus will be suspended from the top of the traveler and can quickly and easily be put in position or removed. A narrow working platform protected by hand rails will be provided on each side of the hydraulic apparatus for the men who will operate it. The jack will be seated on a table provided with adjustable reaction pins allowing it to be set in different positions corresponding to the varying lengths of chord pins.

The rivets in the lower chord splices will be driven by a special yoke machine operated by pneumatic pressure. The machine weighs about 20,000 lbs with pin and will be handled by a balance beam supported on a 4-wheel truck running on the two lines of inside stringers nearest the truss. The truck will have cast iron turntable plates carrying a pivoted cast iron pedestal with vertical jaws through the upper part of which there will be a 2½-in. horizontal pin serving as axis and fulcrum through the center of a balance beam or lever 20 ft. long. This will be made with a pair of 8-in. channels back to back with separators between them. At one end the riveting machine will be suspended from its center of gravity free to turn in any direction, and at the other end a U-shaped iron rod will be riveted to the webs to serve as a handle. This beam can revolve 360 deg. around its vertical axis and about 10 deg. each way from the horizontal around its horizontal axis. It can be operated by one or two men and provides for the quick and easy movement of the riveting machine.

In view of the fact that the members composing these trusses have been built as large as can be shipped on ordinary railroad cars, that it has been necessary to ship the largest ones in halves and field-splice them together, and that the hoisting engines, tackles and derricks have been designed especially for this work and have required the largest and heaviest equipment found in the market, it is evident that any material increase in both the span and capacity of the bridge would involve requirements that could not be met by existing appliances. Many of the devices would have to be of different designs and the units and sections would need to be so large as to be made and handled with difficulty. Many of the methods of the work could not be indefinitely extended and new ones would have to be developed involving very elaborate and costly construction and operations and causing delay and hazard. It is evident from the experience gained on this work that the cost of erection per pound is much larger for very heavy work than for work of moderate weight; for instance, half a dozen 10-ton pieces can be handled much more quickly and cheaply than one piece weighing 30 or 40 tons, the former can be quickly picked up with simple devices while it may take several hours to secure the latter with special clamps and lock. It is therefore believed that the limit of size for economical erection under present conditions and existing types of machinery and plant is nearly or quite attained with the structure under consideration, and that if spans of materially greater combined lengths and capacity are to be built, it would be decidely advisable, from the erector's standpoint, to make them with twin trusses reducing the dimensions of separate pieces.

The bridge was designed and is being built under the direction of the department of bridges of New York. The contract for the manufacture and erection of the superstructure was awarded to the Pennsylvania Steel Co., Mr. J. V. W. Reynders, vice-president; Mr. Thos. Earle, superintendent of the bridge and construction department; Mr. Fred W. Cohen, engineer of erection, and Mr. L. N. Gross, general foreman of erection. The method and plant of erection have been described in the Engineering Record of March 4, 11 and 18, 1905.



Views of Main Trucks for No 2 Traveler, Blackwell's Island Bridge

Rapid Plate Girder Erection with a Derrick Car.

An example of bridge erection which undoubtedly makes the record for the most rapid work yet accomplished on long span plate girder viaducts was very successfully carried out last winter by the American Bridge Co., of New York, in a portion of the double tracking of the New York, New Haven & Hartford R. R. The viaduct in question included fifteen 90-ft. deck spans of old lattice girder superstructure which were replaced by plate girders, two additional lines of plate girders being also erected parallel to them for the second track. It was required that the erection should be completed by March 15, 1905, and when in the latter part of February it had not been commenced the railroad company expected that the job would require several months, and believing that they foresaw a long delay, became very anxious. The bridge company had planned to erect the viaduct with a derrick car which they were making vigorous efforts to complete in their American shops. As soon as it was finished it was shipped from Pittsburg in a fast freight train at 1 P. M. and was received in Jersey City at 7 A. M., the next day. The car was immediately transferred to the work and commenced operations February 25, completing the structure ready for train service March 10.

The derrick car was seated at first on the new track, not yet under traffic, at one end of the bridge. The girders were delivered to it, without being unloaded from the flat cars on which they were shipped from the shops, and were in the intervals between trains brought alongside on the old track still in service. They were unloaded from the cars and set in their required position on their permanent seats by single operations, being handled by the 50-ft. boom of the derrick car, which advanced on each span as soon as it was erected. The average time required to unload a girder and put it in place was only about 25 minutes. The 30 girders for the 15 spans of one track were thus erected in seven days. As many as six girders were erected in a single eight-hour day. The speed of erection was limited by the time required to deliver the girders and the necessity of handling them in the intervals between the frequent trains.

The derrick car was designed to be simple, powerful, easily moved and quickly put in service, and had a sectional boom of 30 tons capacity which could be made 25, 50 or 75 ft. long as required. The car was made entirely of steel with four heavy longitudinal girders and is mounted on two of the heaviest standard car trucks with capacities of 70,000 lb. each. It weighs about 70 tons, and is provided with a locomotive gear enabling it to travel independently at speeds of 4 or 5 miles an hour. The boom is easily unshipped for transportation and when in service is operated from a heavy A-frame without a mast. It is equipped with a 2-drum, 4-spool Rawson & Morrison hoisting engine and a 50-h.-p. boiler.

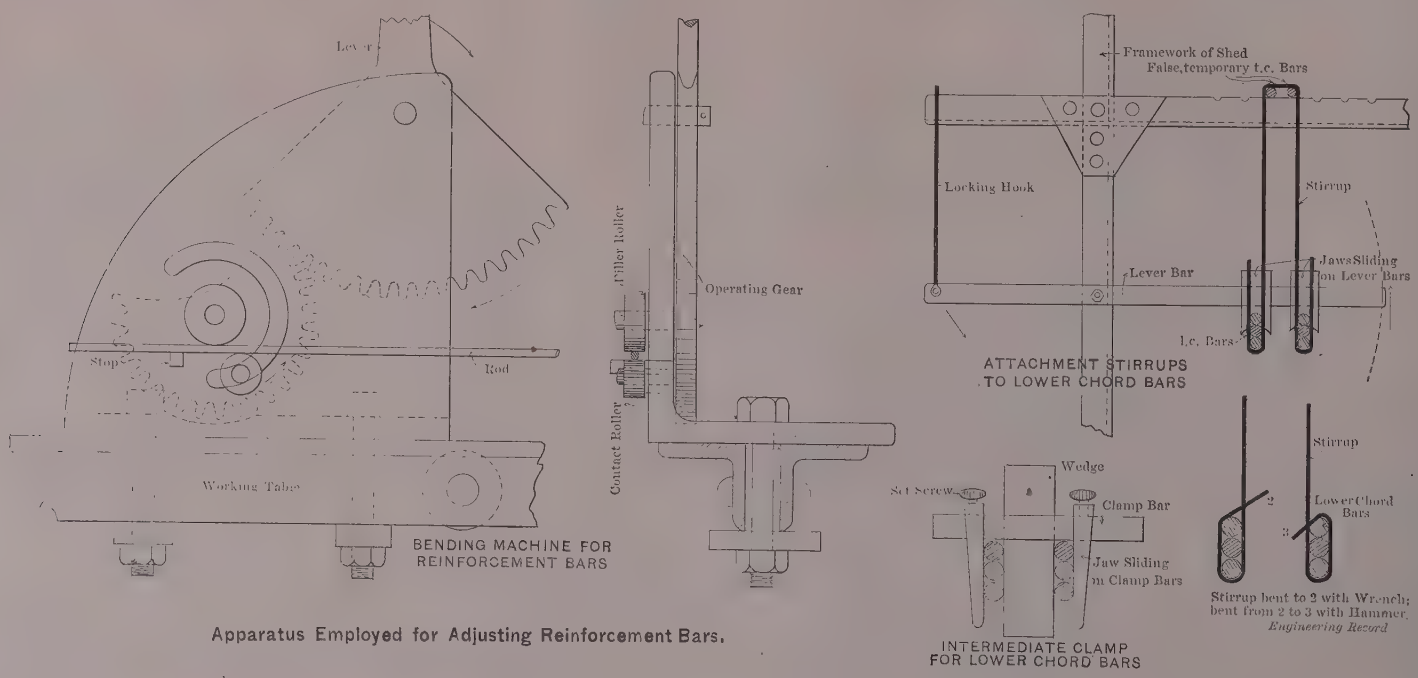
An auxiliary boom was rigged on each side of the A-frame and these were used for anchoring the derrick car against the heavy eccentric loading required to lift the 32-ton girders from their positions on the cars 18 ft. beyond the center of the derrick car. A group of small girders weighing about 7 tons was attached to the hoisting tackle of one of the side booms and lowered to rest on the thick ice which at this time covered the river. The tackle was set up to nearly lift the girders and served to hold the derrick very firmly while handling the long girder. When the derrick car was advanced the anchor was hoisted by the main boom which carried it on the center line of the car until a new position was reached when it again lowered it to the ice and the falls of the side boom were set up without ever having been released from the anchor, thus making the operation of securing the derrick car very rapid and easy.

The derrick car was operated by 15 men and in 15 days erected over 1,000 tons of steel which, with the ordinary method, would have required a party of 25 men at least three months, thus effecting a very notable saving in both time and expense. The derrick car was one of a set of four especially designed by Mr. S. P. Mitchell, C. E., chief engineer of the American Bridge Co., of New York.

ERECTION OF A REINFORCED CONCRETE FACTORY FOR THE BUSH TERMINAL COMPANY.

The 75x300-ft. seven-story factory building for the Bush Terminal Co., in South Brooklyn, N. Y., has six reinforced concrete floors calculated for loads of 800 lb. per square ft. which are supported on long-span reinforced concrete girders and circular columns of special construction, as described in The Engineering Record of January 13, 1906. The design is special as regards the floor slabs which have a corrugated cross section eliminating the use of floor beams, and the columns are novel in that they consist of a monolithic stone concrete shaft hooped with spiral steel wire and enclosed in a thin shell of cinder concrete which serves both as a mould for construction purposes and as a permanent fireproof jacket, but is not relied upon to carry any load.

All concrete except in the foundations was made 1:2:4 with Atlas Portland cement, machine mixed and used wet. The reinforcement in the girders which carry the floors and in those which distribute the column loads over the pile footings is made with round steel bars with their ends bent upwards and hooked to insure superior grip in the concrete. They are securely wired to vertical shearing rods arranged according to the requirements of the stress diagram. This construction is completed in a shop where the reinforcements for the girders are systematically assembled and fastened so securely together that they virtually form independent trusses so rigid that they can be stored, transported, fastened in the moulds and will resist the ramming of the cement around them without becoming displaced or distorted. This property insures very positive and exact location of the steel in the concrete in the theoretical position shown on the drawings. It is considered to save time and systematize operations to a valuable degree and is a characteristic of the Bertine system of construction under which this building has been designed.


Lever
Stop
Rod
Working Table
BENDING MACHINE FOR REINFORCEMENT BARS
Filler Roller
Operating Gear
Contact Roller
Framework of Shed
False, temporary t.c. Bars
Locking Hook
Stirrup
Lever Bar
Jaws Sliding on Lever Bars
l.c. Bars
ATTACHMENT STIRRUPS TO LOWER CHORD BARS
Wedge
Set Screw
Clamp Bar
Jaw Sliding on Clamp Bars
INTERMEDIATE CLAMP FOR LOWER CHORD BARS
Stirrup
2
3
Lower Chord Bars
Stirrup bent to 2 with Wrench; bent from 2 to 3 with Hammer.
Engineering Record

Apparatus Employed for Adjusting Reinforcement Bars.

The excavation and the construction of the foundation piers, footings and cellar floor were made by separate contracts and the erection of the superstructure upon them formed an independent contract. Operations for it were commenced by setting the permanent column moulds in position on the finished cellar floor and enclosing them with falsework to carry the special moulds for the column tops. The deep rectangular moulds for the longitudinal girders connecting the columns were seated on the falsework and acted not only as self sustaining girders of spans up to about 6 ft. clear, but also served as supports on which the moulds for the corrugated floor were carried.

The girder moulds were of simple construction built by the carpenters at the site. The moulds for the corrugated floor slabs were duplicated and were accurately made to order in large numbers at planing mills. Enough falsework and moulds were provided for one complete floor and were used over and over again with comparatively slight changes and repairs for the six upper floors, thus effecting considerable economy of labor and material besides having left at the completion of the work almost the total amount of still serviceable moulds.

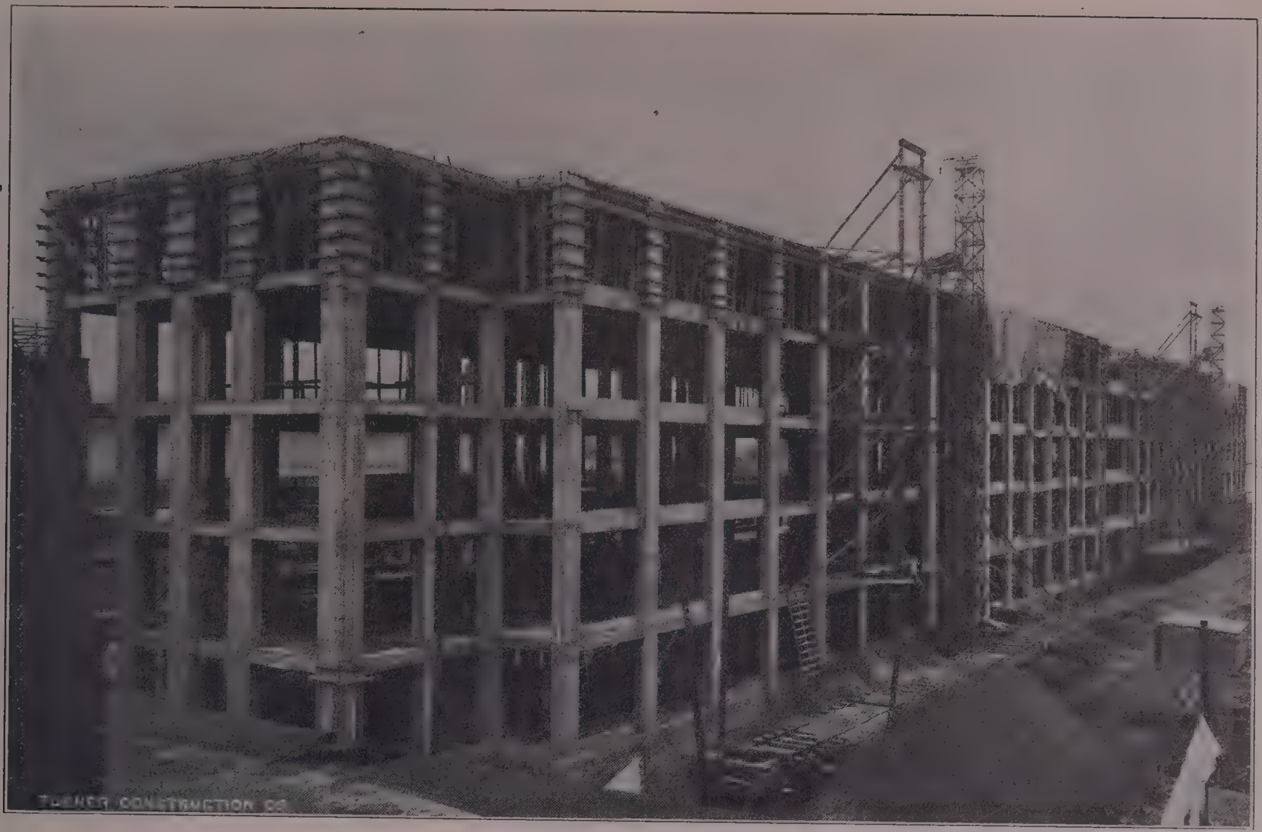
The cost of the falsework of this building was about 8 cents per square ft., equivalent to 10 per cent. of the total cost of the building, a proportion which was considered by the contractors to be excellent for this class of work. This estimate is based on the fact that about 50 per cent. of the centering is available for another building about to be erected. Special care was taken to design the falsework in such a way that the columns can readily be made first and that all important portions of the work follow in regular sequence and can be under construction simultaneously in different parts of the building. In this way the moulds for the first half of each floor were being removed from one end towards the center and carried up one story to be erected there in the same order while the second half of the same floor was being concreted from the center towards the opposite end.

With a total force of about 150 men, the building was constructed at the rate of one story in about eighteen 9-hour working days; about 3 weeks were required to set all of the moulds for one floor and a maximum amount of 2,500 square ft. of floor concrete was made in one day, each mixer turning out 90 cubic yd. of concrete, an amount limited by the rapidity with which it could be removed and put in position. Concrete materials were delivered on a standard gauge railroad siding running the full length of the building close to one side on top of a timber trestle about 12 ft. high, the sand, gravel and broken stone being all dumped through the trestle and stored in piles which contained about 800, 1,000 and 1,000 cubic yd. respectively. Cement was delivered from the same track and chuted to small houses with a capacity of about 1,000 bags each.

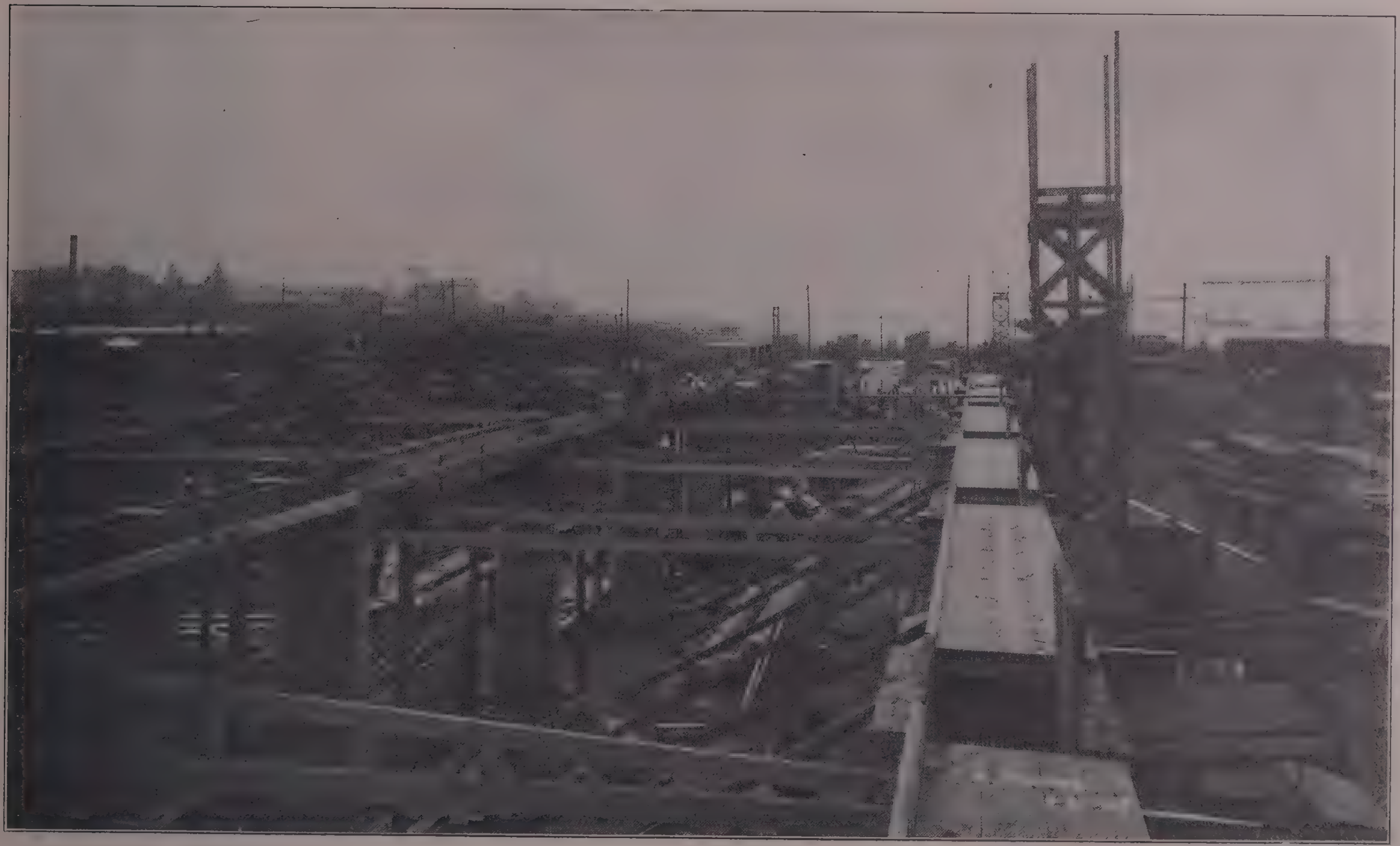
The Ransome mixers were supplied with sand and broken stone by Ransome cylindrical dumping carts and they delivered concrete directly to the automatic dumping buckets of the Ransome elevators. The elevator buckets discharged to bins about 4 ft. above the successive floors, where the small quantities of concrete were stored sufficient for the constant supply of wheelbarrows which were loaded from them by scraping the concrete through a chute and gate. The barrows were wheeled on single plank on top of the floor moulds and dumped wherever desired, the concrete being carefully spaded around the reinforcement steel in the moulds. There were also two cage elevators running between vertical guides and having 7x20-ft. platforms suited to handling the 20-ft. reinforcement trusses which were carefully adjusted in position in the girder moulds and held by blocks and wiring. The lower rods of these trusses as well as the rods in the floor troughs were seated on small concrete blocks which had projecting anchor wires transverse to the moulds. The reinforcement rods in the floor troughs are slightly longer than the floor panels and the ends overlap the longitudinal girders, alternating with the bars in the staggered troughs in adjacent panels.

In order to provide bolt holes in the ceiling for the convenient attachment of machinery, etc., horizontal 1-in. tin tubes 4 ft. apart were set transversely in many of the floor moulds and remain embedded in the concrete.

After the column girders and floor moulds were filled with concrete to the floor level the upper surface was carefully floated and smoothed. After it had set about a week the cylindrical column moulds in sections of about 30 in. long were distributed on it and one was set in each required position, another was placed on it and so on until they were built up to the necessary height, their joints being made with cement mortar applied with a trowel as for ordinary brick or tile setting. Each mould of the basement columns was centered around four ⅝-in. vertical dowels which projected 2 ft. above and 2 ft. below the floor surface and served to bond the column in position. Above the basement these dowels were omitted. The moulds were each surrounded by



Exterior View of Building During Construction



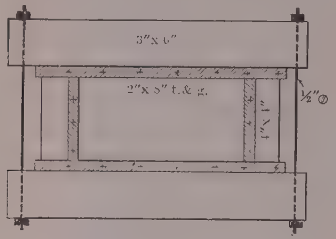
View Taken on Second Floor of Bush Terminal Factory, Showing Cylindrical Column Shells and Molds for Beams

a skeleton frame-work composed of 4x4-in. vertical timbers connected by upper cross pieces on which the girder forms were seated as already described.

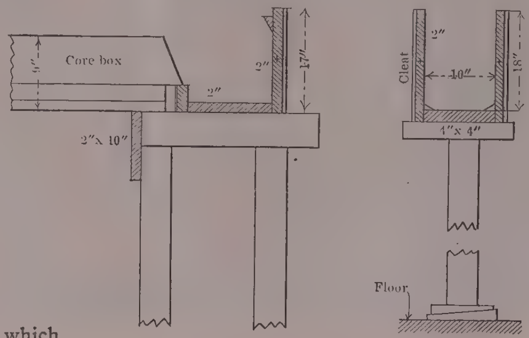
The moulds for the wall columns or piers were rectangular wooden boxes made with tongue and groove vertical boards 1 in. thick. The boards on each side were fastened together with battens so as to make single panels which were erected separately. The panel in the outer face of the wall was first erected and was carefully plumbed. The other three were then assembled to it by means of horizontal yokes about 3 ft. apart made with 3x6-in. side pieces united by half-in. bolts as shown in the cross section detail and the top of the mould was braced by 45 degrees laths in three directions, the inner laths being nailed to cleats bolted to the floor.

All of the wooden moulds were thoroughly painted with petrolatum each time before they were used. The levels of the longitudinal girders were exactly adjusted by pairs of wedges under the footings of 4x4-in. verticals. The moulds for the main longitudinal girders had side pieces made with pairs of 2-in. planks battened together to form complete sides handled as units. Triangular fillets were placed in the bottoms of the moulds to chamfer the corners of the concrete beams. The moulds were supported at intervals of about 6 ft. by intermediate vertical falsework posts with their tops bearing against 4x4-in. transverse battens across the bottom boards of the moulds.

About 2,000,000 lb. of steel rods from ¼-in. to 1½-in. in diameter were required for the reinforcement and were received in carload lots and stored in racks under a shed provided for the purpose. The main rods were ordered cut to length, but the rods for the vertical members were received in lengths of about 20 ft. and were cut as required. A shed was provided for the steelworkers and in it about 12 men were employed in cutting and bending the reinforcement rods and in fastening them together to form the frameworks for the different girders, of which there are in all about 50 different patterns.



HORIZONTAL SECTION OF WALL PIER MOULD



SECTIONS THROUGH GIRDER MOULDS

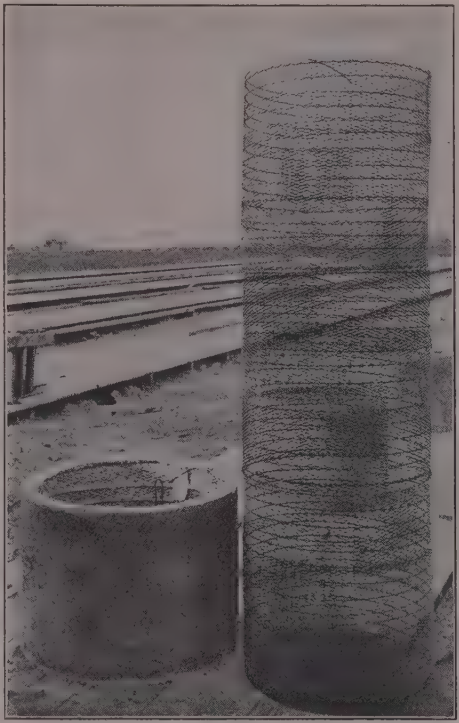
Engineering Record

All steel work was done by hand, the heaviest rods being bent by powerful compound levers to the simple shapes required. The lighter rods were bent with an eccentric geared lever pivoted to a cast iron plate and arranged so that a pin on the operating wheel revolved around a fixed point and bent the rod as desired, nominally shaping it to a template. In fact, however, the workmen became so expert that they bent the rods to the required curve with great accuracy without using the templates. The bending plate was set in a vertical position and was clamped to a skeleton table through its horizontal flange as indicated in the sketch. With it one man could bent ⅜-in. rods 180 degrees rapidly. The rods were cut with Manning, Maxwell & Moore shears.

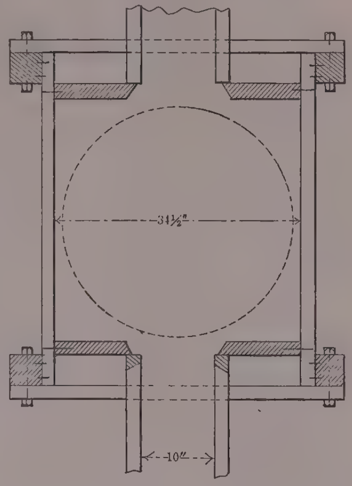
The reinforcement trusses were assembled by a regular routine which provided a simple and systematic method of handling them and enabled the workmen to become so expert that two men working together could complete many ordinary trusses in one day. The vertical posts and horizontal members of the skeleton framework of the shed formed a support on which the trusses were assembled. A pair of temporary horizontal rods, like a false top chord for the truss, was placed across projecting horizontal supports and on it the inverted U-shape stirrup rods with hooked lower ends were placed. The lower chord bars were then suspended in the stirrup hooks spaced according to marks made on the upper horizontal bar. The truss was held in a vertical position at the proper location by means of spacing blocks and wedged clamps and the chord bars were forced downwards by means of saddles engaging the upper side which were clamped to a pivoted horizontal lever. The opposite end of the lever was raised and instantly hooked in position to the framework of the shed so as to hold the chord bars sprung down under initial tension. The looped ends of the stirrups were then bent with special wrenches about 120 degrees so as to engage the chord bars and were afterwards hammered down to position and firmly wired. As fast as the trusses were completed they were removed to the storage yard and piled up with blocking in layers, making stacks several feet high of the different types of trusses.

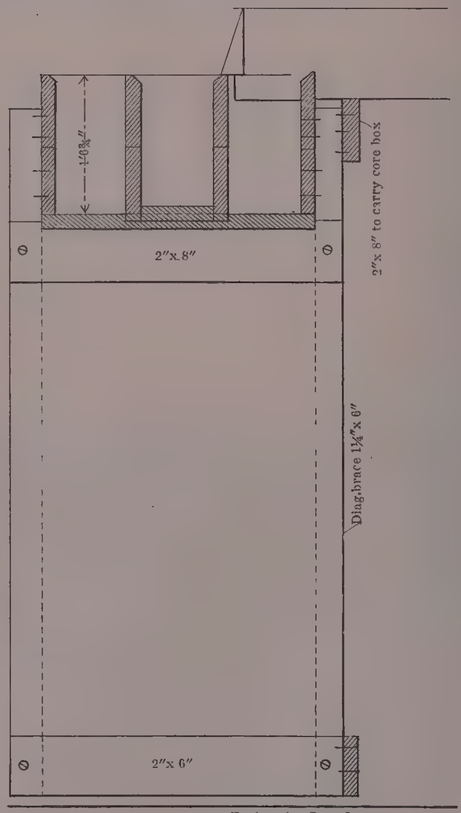
As before stated the permanent fireproof moulds in which the columns were cast were made with sectional reinforced concrete hollow cylinders from 12 to 30 in. inside diameter, 1½ in. thick and about 30 in. long. The first step in the construction of these shells was to wind the helical steel wire on a collapsible mandrel about 4 ft. long which was mounted on a horizontal axis and turned by hand while the wire was also fed over it by hand under moderate tension. The mandrel had a wooden shaft to which were attached 8 equi-distant radial wooden plates or diaphragms with their outer edges forming elements of the required helix. Two pairs of these diaphragms were made with a hinge joint near the outer edge parallel to the axis so that after the skeleton of the mould was formed on it they could be collapsed to facilitate its removal.

After the wire was on the mandrel a sheet of expanded metal cut to the proper dimensions was wrapped around it with the longitudinal edges lapping a few inches and carefully wired together and wired to the helix at alternate points. This metal framework was removed from the mandrel, taken to the casting floor and centered inside a vertical cylindrical mould made of wood and lined with zinc. The mould was made in halves, keyed together with octagonal horizontal flanges at both ends. It was set on a horizontal platform and the space between the metal core and the mould was filled with 1:5 concrete made with fine cinders and Atlas Portland cement. After it had set 18 hours the moulds were stripped and the concrete shells were removed for storage or to be used in the building. The large shells weighed about 150 lbs. each and were easily handled by a pair of wire loops attached to the helix and eventually embedded in the concrete of the column.


Column Shell Reinforcement

This factory is one of 18 which are planned for the Bush Terminal Company, Mr. I. T. Bush, president and Mr. E. P. Goodrich chief engineer. Mr. R. F. Tucker was consulting engineer, Mr. William Higginson, architect, and Kirby, Petit, and Green were the designers of the exterior elevation. The Bush Company provided all materials and the Turner Construction Company was the contractor for the labor and superintendence for the work here described, which was executed under the personal supervision of Mr. DeF. H. Dixon, C. E. The detailed structural drawings were prepared under the direction of Mr. R. L. Bertine, C. E., and the reinforcement work was executed under the direction of Mr. P. E. Bertine. The reinforcement steel was bent, cut and assembled by the Roob Iron Works under the direction of Mr. M. T. Hamsley, who designed some of the appliances used. The steel was purchased from the Carnegie Steel Company and the cement was tested by the Pittsburg Testing Company.





Engineering Record

Falsework Supporting Floor Moulds

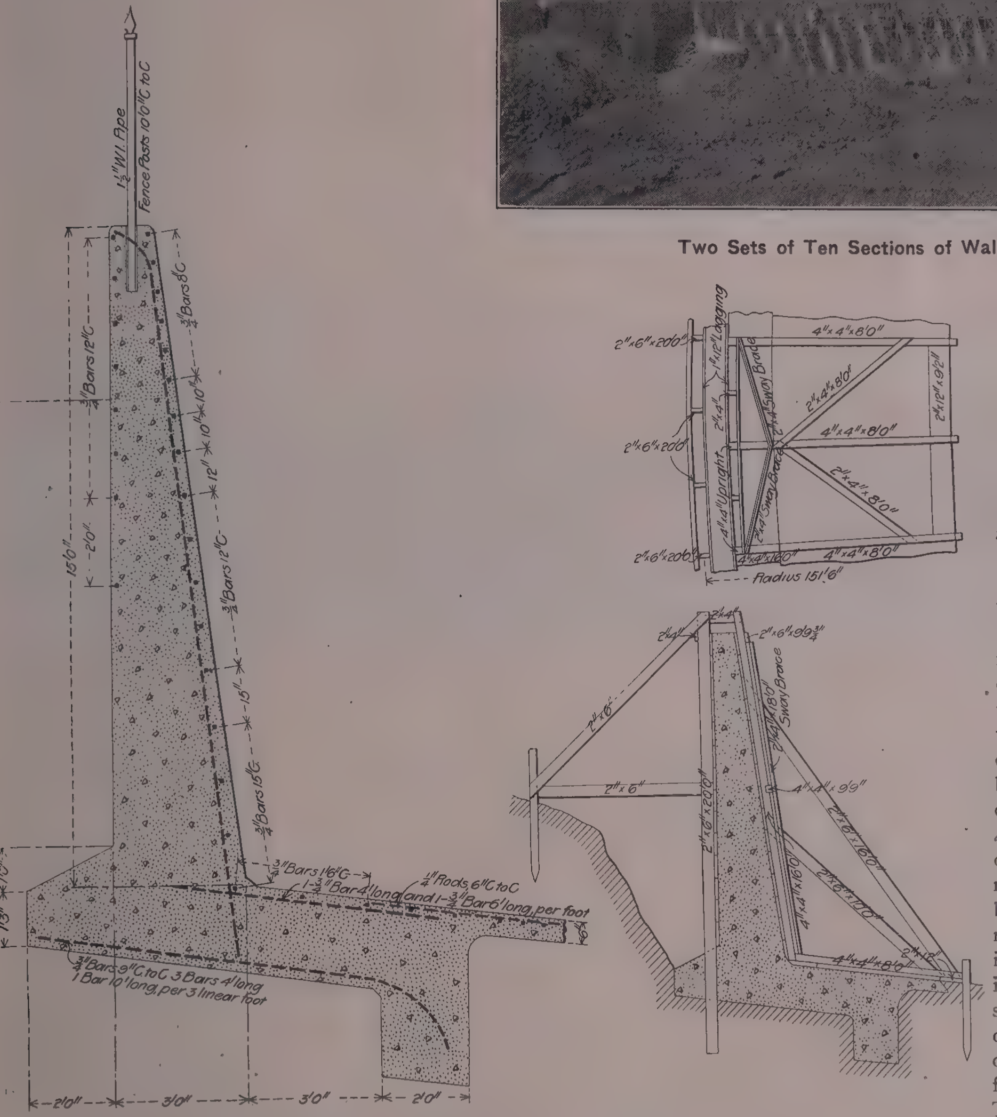
A Reinforced-Concrete Reservoir at Bloomington, Ill.

An open, circular reinforced-concrete reservoir, with a capacity of 10,000,000 gal., has recently been built in connection with the water-works system of Bloomington, Ill. The water supply of Bloomington is drawn from twelve 10-in. wells, 90 ft. deep, near a station containing service pumps which supply the distribution system under direct pressure. Several of these wells were sunk a number of years ago, the water being pumped from them and delivered into a conduit leading to a suction well at the pumping station by an air-lift installation. Prior to the construction of the reservoir and other improvements, the supply was occasionally inadequate for even normal consumption. The fire protection afforded by the water-works system was entirely insufficient, as a stand-pipe 7 ft. in diameter and 225 ft. high, which served principally as a pressure regulator, provided the only storage capacity. Furthermore, the distribution system being under direct pressure from the service pumps, offered an additional hazard. To increase the supply the old wells were overhauled, their strainers removed and replaced, and several new wells driven. A new air-lift system was also installed and water can now be drawn from the twelve 10-in. wells and delivered to the new reservoir, which provides suction storage for the service pumps.

The supply available from these wells under the former arrangement of practically direct draft from them to the distribution system might have been great enough to provide for normal consumption, which is about 2,000,000 gal. a day. It was, however, entirely inadequate for fire protection unless the excess flow obtainable during periods of low consumption could be stored. The land in the town and its vicinity is so flat that no suitable elevation was available for a storage reservoir which would supply the distribution system by gravity. For that reason a storage reservoir between the wells and the service pumps was considered the most feasible arrangement. A portion of the only site available for such a reservoir at the station was formerly an old sand and gravel pit, and the site was also over a pervious stratum of sandy gravel. It was desirable that all the water should flow by gravity from the reservoir into the suction pipes of the service pumps, and at the same time that the height to which the water would have to be raised by the air-lift should not be excessive. To meet these conditions, the reservoir had to be placed largely in excavation.

The reservoir is 300 ft. in diameter and has a side wall 15 ft. high, vertical on the back and with a batter of 2 ft. on the front face. The surface of its bottom is a segment of a sphere, the depth of the reservoir varying from 15 ft. at the wall to 25 ft. at the middle. The nearest point in the wall to pumping station and suction well is 75 ft. from the former and 125 ft. from the latter. The water drawn from the 10-in. wells by the air-lift is delivered through a 20-in. pipe inlet to the reservoir, the wells being 6 to 200 ft. from the inlet. A 24-in. cast-iron pipe leads from reservoir to the old suction well, where it is divided in two 18-in. branches, one of which is connected to the suction pipe of each of the two direct-pressure service pumps. These 18-in. branches and the suction pipes are fitted with hydraulic gate valves, so arranged that the pumps may draw either from the suction well or from the reservoir. A 16-in. overflow, set 1 ft. below the top of the reservoir wall, is provided. The maximum suction head on the pumps will be 26 ft. with the reservoir full.

Two Sets of Ten Sections of Wall Forms Approaching Closure.



Cross Section of Wall and Forms for Building It.

The design of the structure is so evident from the accompanying cross-section of the side wall and a portion of the floor that few explanations are necessary. The embankment around the reservoir is within 4 ft. of the top of the side wall. The wall, which is 1 ft. thick at the top, and 3 ft. thick at the bottom, is built with a footing 10 ft. wide, having a toe on the inner side 4 ft. deep below the bottom of the resrvoir and 2 ft. wide. This footing is reinforced near the bottom with transverse ¾-in. Johnson bars, 9 inches center to center. Every fourth one of these bars is 10 ft. long and is bent down into the concrete toe of the footing. The other bars are 4 ft. long and have one end just inside the back of the footing. The footing is also reinforced near its upper surface on the water side by ¾-in. bars on 6-in. centers. These bars are alternately 4 and 6 ft. long, and all extend 18 in. into the concrete under the wall. The wall proper is reinforced with vertical ¾-in. bars near its surface on the water side. These bars extend down into the footing, and their spacing is reduced from 4 to 6 and then to 12 in. on centers from the bottom of the wall to the top, as shown. The wall is reinforced for temperature stresses near both faces by ¾-in. horizontal bars. These are placed varying distances apart, depending on the liability of extreme changes of temperature, and inside the back face are omitted below the frost line.

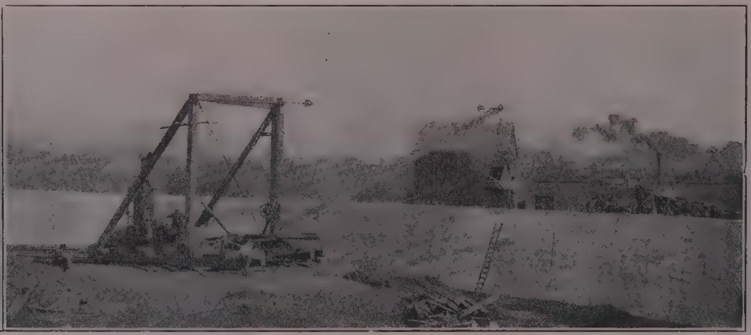
The wall is built entirely without expansion joints. The range of temperature to which the concrete in it below the water line will be subjected is comparatively slight, and will rarely, if ever, be brought about suddenly. If a sudden and great change should occur, the shape of the reservoir will assist in taking care of the stresses that will be set up. The floor of the reservoir is 6 in. thick and is also built without expansion joints, the whole structure thus being practically a monolith. The floor is reinforced with a mat of ¼-in. round rods placed 6 in. on centers in both directions.

The wall has a fence on top built of 1½-in. wrought-iron pipe posts, with two 1¼-in. horizontal pipes between the posts, and woven wire fencing strung on the posts and intermediate pipes. Sockets of 2½-in. wrought-iron pipe, 18 in. long, were set vertically in the wall with their tops flush with the top of the concrete as the latter was laid. The posts are placed in these sockets and the space between the post and the socket poured with lead. The 1¼-in. horizontal pipes pass freely through branches of 4-way crosses, built in the posts; each of them is continuous, the lengths of pipe of which they are made being joined together with couplings.

The construction of the reservoir was commenced Aug. 20 last, and it was essential that the reservoir be completed and placed in service in the shortest possible time, at least before cold weather set in. The construction, therefore, had to be carried on as rapidly as feasible and at the same time the highest grade of concrete work had to be done, as the structure was built under a guarantee to be water-tight for at least five years.

While a concrete mixing plant was being set up and the concrete materials delivered, a Page scoop-bucket excavator was placed in operation digging the trench for the 24-in. connection between the reservoir and the suction well. Before this excavator could be built and set up, the trench for the footing of the wall had been dug by teams and scrapers, and finished smooth by hand with shovels. The excavator used is shown in one of the accompanying illustrations. It consists of a 1½-yd. excavator bucket mounted on the 50-ft. boom of a stiff-leg derrick. The bucket is a rectangular sheet-steel scoop, open at one end and partially open on top. It is swung from both ends, and the bottom of the open end is shod with a cutting edge. It is filled by being pulled along the ground towards the derrick platform by a hauling cable attached to the open end of it and to a drum on a hoisting engine on the platform; it is lifted back out to the boom point by a hoisting cable when filled, the hauling cable being kept taut meanwhile by a brake; and is finally dumped by slacking off the hauling cable. The excavator is mounted on rollers and is moved backwards as the work progresses. The derrick boom can be swung through about 240 deg. by a bull wheel and the bucket filled or dumped at any point within this range.

The Concrete Mixing Plant.



The Scoop Bucket Excavator

When the pipe trench had been dug to grade the excavator was started on the first cut inside of the footing wall, the position of the excavator being at all times such that the bucket could be dumped outside of the completed wall. An 80-ft. circular strip was taken out in this manner, the excavator working practically down to grade. A strip of earth wide enough to carry a service track had been left across the wall where the excavator came into the reservoir. A track was laid from the excavator along this strip of ground and across the wall to a spoil bank about 200 ft. from the reservoir. A trap for loading dump cars was erected over this track, within the range of the bucket, and 1¼-yd. Western dump cars were loaded through it with the material from the excavation, trains of 3 of these cars being hauled out to the spoil bank by horses. The excavation, with the exception of a small portion of the strip carrying the track, was completed in this manner. This last portion of the strip was taken out in 1-yd. buckets which were filled by hand and hoisted over the wall by the excavator.

The wall was commenced as soon as practicable after work had been started on the circular trench for it. The concrete mixing plant was set up outside of the site of the reservoir along a side track from the railroad. The concrete materials were delivered on the side track, except some gravel from the excavation that was used. A Foote portable continuous mixer was used in making the concrete for the wall footings and the wall. It was mounted so it could discharge into dump cars on a service track laid on the ground. A double hopper was built up over the mixer, one compartment for sand and one for broken stone. The end of a service track leading from the side track was laid on an inclined trestle up to a floor level with the top of this double hopper, the materials being hauled in dump cars from the side track to the hopper. The service track from the mixer extended entirely around the wall, and 10 ft. from it, on the embankment made there with earth from the trench for the wall-footing. The concrete was dumped from the cars on the service track to portable shoveling platforms near the point where work on the wall was in progress. It was shoveled by hand from these platforms to place in the forms, as the presence of the reinforcement bars in the narrow forms precluded dumping in large quantities. The footing was built without forms up to the right-angle joint between it and the base of the wall at the front, and to the top of the 45 deg. slope on its rear face. A layer of concrete 2.5 in. thick was first placed in the completed trench. The reinforcement bars near the bottom were then laid on this green concrete, the vertical bars near the front face of the wall usually being erected at the same time. The concrete in the toe of the footing and in the footing proper up to the top layer of reinforcement was then laid. After the top layer of reinforcing bars had been laid, the footing was completed, except for a top layer about 2 in. thick at the base of the front face of the wall and 15 in. thick at the toe of the footing. This left a strip of surface about 6 ft. wide, sloping at about 1 in 6 from the wall toward the center of the reservoir, and furnished the widest and best possible bond for the joint which had to be made when floor was laid.

Location and Construction of Forms and Wall.—The design of the wall of the reservoir, although simple in itself, required unusually accurate work in the location and construction of the forms for it. The location was made with very little difficulty, however, by an arrangement devised by the contractor which enabled the foreman, without the aid of an engineer, to set the necessary grade and reference stakes. A post, 10 in. in diameter, was set very accurately and firmly in the ground at the center of the reservoir. This post was sawed off squarely on top so that the line of collimation of an engineer's transit set on it without a tripod would be exactly at the grade of the top of the completed wall of the reservoir. A 200-ft. steel tape was used to measure the radial distance from a nail in the center post to the posts of the back, or outside forms for the wall. In the form for the back face of the wall 2x6-in. posts, spaced one one-hundredth of the circumference apart, were set considerably in advance of any concrete work, and were made the basis of all measurement in building the forms. The forms as originally planned are shown in one of the accompanying illustrations. One or two slight modifications were made in actual construction by the contractor, in order to meet local lumber conditions.

The wall, when started, was built continuously in both directions from the starting point. The back forms consisted of planks for lagging nailed to vertical posts, which were accurately set and firmly braced. The front forms were made in lengths equal to one one-hundredth of the circumference of the reservoir, and when set up were fastened to the back forms. Twenty-one of these front form sections were built and all set up at once. Concrete was filled in between the front and back forms, starting at the central form, and was rammed in inclined layers, sloping, at about 1 on 6, both ways towards the end forms. This method was adopted in order that the concrete might be laid continuously and without joints. The lagging of 1-in. boards on the vertical portion of the sections was nailed to the vertical posts, and was carried up just ahead of the concrete filling.

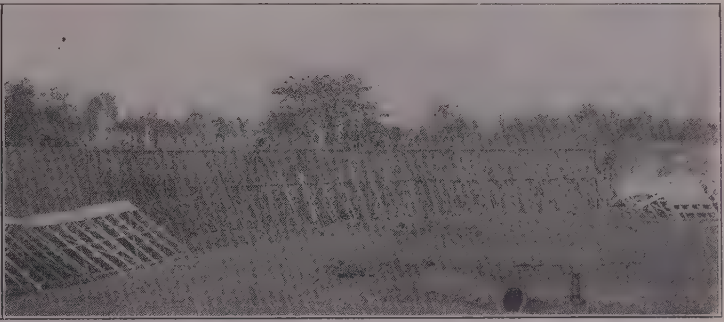
When the concrete had reached the top of the central one of the 21 sections of the forms, and the concrete in that section had set sufficiently, the section was broken up and removed, leaving two sets of 10 sections of the forms. Subsequently the other forms could be removed in turn as desired without being broken up. As the filling in proceeded between the two sets of 10 forms each, the form in each set nearest the starting point was removed, carried forward, and put in place at the other end of its set of forms. Twelve men were required to take down and transport one of the front form sections.

In setting up a front form, its inner toe was firmly supported by a stake driven into the ground and by the horizontal board, nailed transversely under the bottom 4x4-in. horizontal stringers, which rested on the ground. The upper part of the form was then securely fastened to the 2x6-in. posts of the back forms by temporary wooden connecting strips, which were removed as the concrete filling was carried up. The sections of the front forms were also securely tied to each other.

A facing of gravel concrete, rich in cement and with no pebbles larger than ½-in. was placed on the front face of the wall, extending from the back edges of the vertical reinforcing bars to the surface. A sheet-iron plate, about 8 in. wide by 5 ft. long, was placed vertically just back of those bars. The concrete was shoveled in loose to the top of these iron plates, and then the mortar was poured in between the latter and the front face forms from buckets. The iron plates were next drawn by handles attached to them, and the mortar and concrete tamped together before either had set. In making joints, the old concrete surfaces were always brushed and wet down, and, if necessary slushed with a grout of neat cement before new concrete was laid on them.

Construction of Floor.—The excavation over the site of the reservoir floor was brought accurately to grade 6 in. below the surface of the finished concrete by hand after the scoop-bucket excavator had passed over. In making the excavation the levels were given on radial lines drawn from the ends of the 10-ft. sections of the wall to the center. A rod, on which the elevations of the subgrade at every 10 ft. from the wall to the center of the reservoir were clearly marked, was used in connection with a transit on the center post in locating the elevations of different points in the reservoir floor. By using this method the elevations required were easily found by the foreman in charge without the assistance of an engineer. When the work approached the center, the post was removed and the transit was placed on a portable pedestal which was set on points of known elevation on the finished concrete.

Assembling Sections of Front Face Forms.



Front Face Forms, Completed Section of Wall

The slanting surface left on the top of the footing inside the wall formed, together with the projecting reinforcement rods, an excellent bond between the concrete of the wall and that of the floor, when the latter was laid. A circular strip of the floor, 16 ft. wide, was put down next to the wall first, and the remainder of the floor was laid according to the progress of the excavation. The lower 3½ in. of the concrete was usually first spread out over an area 12 or 16 ft. square, then the reinforcement was placed, and after that the top 2 in. of concrete and a ½-in. sidewalk finish surface were laid.

The ¼-in. rods in the bottom are 6 in. on centers in both directions. They were in 12 and 16-ft. lengths and were partly woven together in mats before being placed. The rods in one direction were all laid out and woven with four or five of those in the other direction, the joints being tied with small wire. The remaining cross rods were laid after the mat had been placed. The mats were overlapped 1 ft. This method of placing proved economical and efficient, giving at the same time something permanent on which to lay the remaining concrete.

Concrete.—Universal Portland cement was used exclusively for the concrete. The specifications required not less than 1 part Portland cement to 2 parts sand and 5 parts clean gravel, and stipulated that there should always be more than enough cement to fill the voids in the sand and more than enough mortar to fill the voids in the gravel. The proportions were varied, depending on the character of the available material and on the location the concrete was to occupy. The stipulations regarding the minimum quantities of cement and mortar were, however, always at least fulfilled. A 1:3:4 mixture of cement, broken stone and gravel was largely used in the footing and wall. The gravel was fine and contained 40 to 50 per cent of sand; the broken stone was the crusher-run, with the dust screened out, and the maximum-sized pieces not larger than those which would pass a 2-in. screen. The mortar facing on the front face of the wall was made of 1 part cement to 4 parts fine gravel, containing sand. Some gravel from the excavation was used in the concrete for the floor. This gravel was so fine that about one-quarter of it was replaced with broken stone and the mixture made 1:6. Both faces of the wall were painted with a 1:1 mixture of cement and sand; the inner face was also painted with a 1:1 mixture of waterproof Star Stettin Portland cement and sand. The sidewalk finish on the surface of the floor consisted of 1:1½ mortar. In order to insure good joints in the floor between work done at different times, the contractor estimates that between 500 and 600 extra barrels of cement were used.

Tests.—The work being done under a guarantee, the city authorities subjected it to some unusually severe tests. Almost as rapidly as the forms were removed the space between the back face of the wall and the bank was flushed with water. The excavator then dumped the earth for the remainder of the embankment into this water, the wall being given a 10-ft. surcharge in places, 10 days after the forms had been removed. Under this test, five places in different parts of the face of the wall showed dampness, or very slight exuding of water. The greatest seepage at any one place did not exceed one or two drops a minute.

The advertisement for the letting of the contract for the reservoir stipulated that each bidder should submit plans and specifications. Eight bids for as many different plans, were received, the bids ranging from $27,000 to about $54,000. The contract was awarded to the Crescent Stone Co., of Peoria, Ill., at $34,000, and the reservoir was completed by that company in a little over 100 days. The plans and specifications were prepared by Mr. Dabney H. Maury, of Peoria, as consulting engineer for the contractor.

A 3,000-kw. Power Plant has been added to the municipal electric plant of Belfast, Ireland, to furnish current for the city's electric railway. It will have three 1,000-kw. units, each having a vertical inverted three-crank triple-expansion engine running at 180 r.p.m. and taking steam at 170 lb. pressure and 150° superheat.

Fuel Purchase by Analysis.

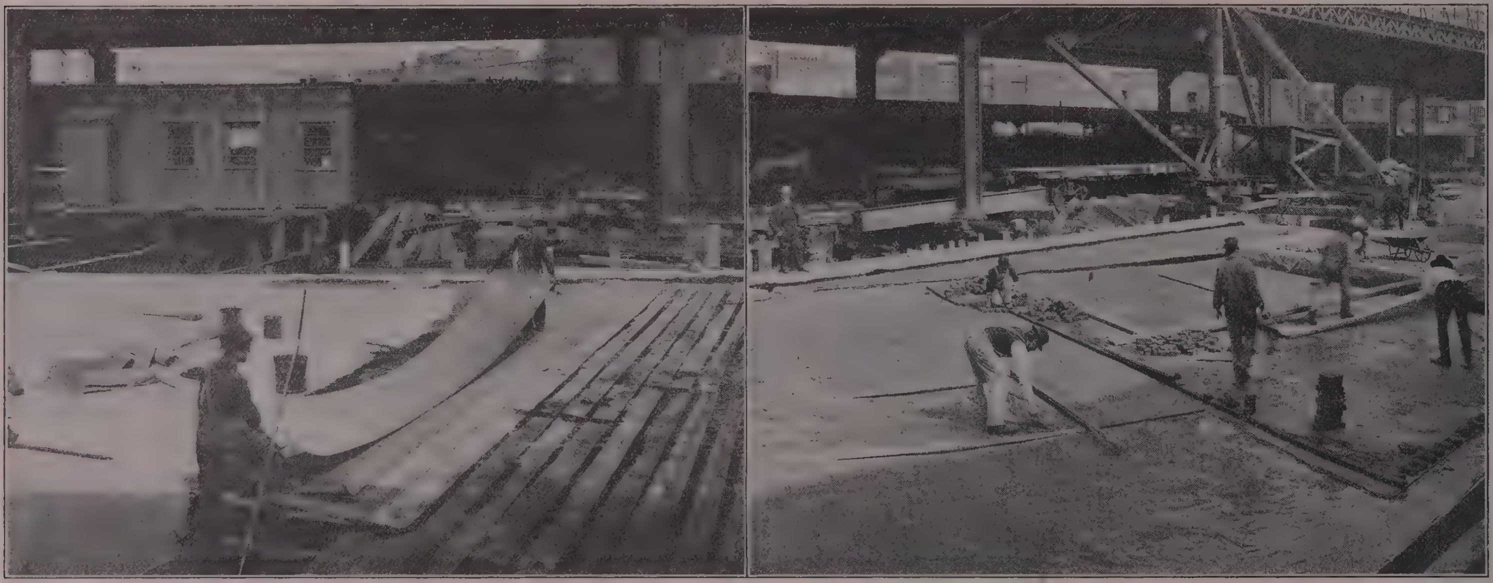
Power station fuel is purchased by an electric lighting company on the basis of an unusual form of contract, described at the convention of the Northwestern Electric Association: After the coal is selected a chemical analysis is made of it, and a contract is drawn in which it is stated that the coal of the sample as delivered corresponds to certain chemical analysis, which is used for the purpose of identifying the coal in the future delivered on this contract. For instance, take a certain coal which costs $2.30 a ton, and the test shows 13,000 B.t.u., moisture 10 per cent. and ash 8 per cent. The contract is drawn on the basis of $2.30 per ton, but if the coal varies in heat units the price is to vary accordingly. The following is the method of determining the B.t.u. Take the original B.t.u. of the coal, 13,000, and if the moisture is 10 per cent., deduct 1,300, which would leave 11,700, which would make the commercial B.t.u. of the coal as delivered. Now multiply that by 2,000 lb. to the ton, which would give 23,400,000 B.t.u. per ton.. As the price is $2.30 divide the number of B.t.u. per ton by that to find the B.t.u. for a cent per pound. Add the cost of removing the ashes at 50 cents a ton, making the basis of the contract in this case about 100,000 B.t.u. for one cent. On a 5,000-ton contract an analysis of the coal is made once a week. The sample is taken by the regular method and analyzed and reported to the consumer, and the contractor. If the B.t.u. for one cent is lower than 100,000, the price drops accordingly, and the price always bears the same proportion to the original contract price. The city of Chicago has canceled all outstanding contracts and let them on this basis, to the amount of 200,000 tons.

The Cost of Underground Ducts for light and power wires has been kept carefully at La Crosse, Wis., and was reported at the convention of the Northwestern Electrical Association by Mr. W. D. Burford. The conduit was 4 or 6-duct McRoy salt-glazed vitrified clay material, laid on 2x12-in. hemlock planks treated with carbolineum. Cleats of 2x2-in. hemlock are nailed to the plank 4 in. from the joints; the conduit is laid on the cleats and the joints wrapped with wet muslin. An iron mold is then clamped around the joint and poured full of Portland cement grout. Two more cleats are placed on the top of the conduit, 4 in. on each side of the joint, and another 2x12-in. plank is laid on top of the conduit. Manholes, 5 ft. in diameter and 5 ft. deep, are constructed of 8 in. of sewer brick. This work cost per foot 25 cents for labor and 39 cents for material for a 4-duct conduit, 28 and 57 cents for a 6-duct conduit, and 45 and 65 cents for an 8-duct conduit, exclusive of repaving charges. The hemlock cost $20 per 1,000 ft., the cement $1.60 a barrel, conduit layers received 30 cents an hour and common laborers 17½ cents.

The Atlantic Avenue Terminal of the Long Island Railroad.

The new terminal station of the Long Island Railroad at Atlantic Ave. and Flatbush Ave., Brooklyn, replaces the former terminal at the same site, and, together with the electrification of the Atlantic Ave. line and the purchase of real estate involves a cost of about $15,000,000. The new structure will be of brick, concrete and steel, two stories high above the street, and will provide for elevated railroad and subway traffic only, no trains entering the terminal at grade. It will occupy an area of about 14 acres including the site of the old terminal and its adjacent yards, the latter being depressed below grade and covered with a solid steel and concrete platform which virtually affords a new street surface on which the two-story superstructure including the passenger station, a branch of the Brooklyn post office, and an express and baggage depot will be built. The terminal will be used entirely for passenger, baggage, express, merchandise, and mail purposes and will be operated in connection with the new depressed freight yards a few blocks distant which are being built simultaneously with it, much of that work being executed in a similar manner by the same contractors.

Underpinning an Elevated R. R. Column



Waterproofing the Substructure Deck at Street Level

The magnitude of the work involved in constructing the terminal, its relation to important traffic and business interests, and the conditions encountered which influenced the design and execution are more clearly presented by the following requirements enumerated by Mr. J. V. Davies, chief engineer of the work:

"(1) The operation of the terminal passenger business of the Long Island R. R. from an underground station below the property of the company at this point.

(2) A thorough operating connection between the Long Island R. R. and the Rapid Transit Subway, contract No. 2, Brooklyn Extension, for eastbound and westbound through business, and at the same time, the arrangement and provision for transfer of business between the Rapid Transit Subway and Long Island R. R. through trains at this point.

(3) The provision for the operation of the express business of the Long Island R. R. This is to be handled in the underground station and operated by elevators betwen the surface and the underground station on Hanson Place.

(4) The continued operation of the meat business of the entire City of Brooklyn to and from the meat warehouses on Fort Greene Place. This will carry a separate structure for the passenger terminal in conjunction with the meat houses of Armour, Swift, Nelson Morris Co., and the other packers.

(5) The separation of the carload freight from the merchandise freight for local delivery in the City of Brooklyn. This involves the construction of a merchandise freight house which it is proposed to build above the roof of the underground passenger station and elevated above the street level. The provisions of the Atlantic Avenue Improvement law provide for the removal of all railroad tracks, other than electric trolleys, from the surface of the street. We, therefore, propose to come in over this property elevated, and to build tracks and platforms for six stub tracks with platform facilities and elevators to lower and elevate the freight to and from the surface of the street.

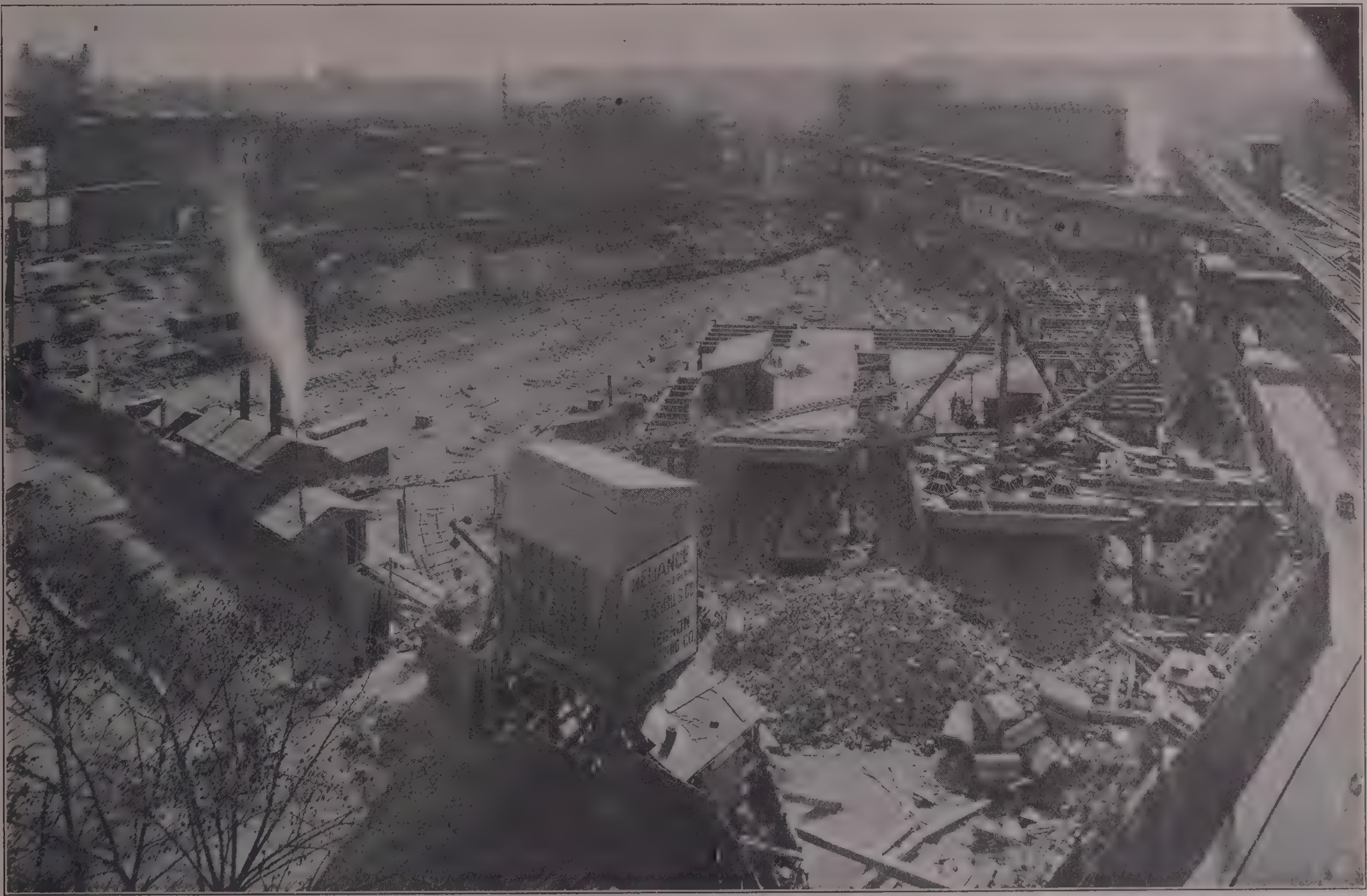
(6) The retention of the arrangement of through operation of electric service between the Brooklyn Union Elevated Railroad (B. R. T.) and the Long Island R. R. Co., at this point.

(7) The depression of the entire freight terminal (10½ acres in extent, and extending 2,400 feet in length from Vanderbilt Avenue to Fifth Avenue) into a big carload freight terminal with accommodation in standing tracks for 429 freight cars. This latter facility is one which has been vitally needed for the business of Brooklyn for several years. For three or four years past the Long Island R. R. Co. has been under the necessity of putting embargoes on deliveries to Brooklyn on account of the lack of room to handle the cars, and this improvement, when completed, will give Brooklyn what it is in the greatest need of—a convenient freight terminal.

In connection with this improvement, it is the intention of the Long Island and Pennsylvania Railroads to put Brooklyn onto the main line, making up through trains there for the south and west as well as for the New England States, to operate either through the tunnels or over the New York Connecting Railroad and the Astoria Bridge, and the work covered by this Improvement gives these facilities, which have never been possible before."

The sub-surface portion of the terminal has a depth of over 20 ft. below the street surface and is of an irregular shape approximately quadrilateral, with extreme dimensions of about 1,100x 480 ft., as indicated in the illustrations published in the supplement of this journal Feb. 10. The terminal is bounded by Hanson Place and Fort Greene Place at right angles to each other and by Atlantic Ave. and Flatbush Ave., which intersect at an oblique angle forming the opposite two sides and providing a curved connection at the narrow end of the yard with the main lines of the Long Island Railroad and with the freight yards which are here built in subway construction similar to that of the New York Rapid Transit Railway. The Brooklyn Branch of the New York Rapid Transit Railway in Flatbush Ave. is tangent with the terminal and has communication with it adjacent to the passenger platforms of the Atlantic Ave. tracks. These tracks are branched to eight stubs served by two side platforms and two island platforms accessible by a passenger sub-subway from the Rapid Transit station. In the triangular space between these platforms, Hanson Place and Fort Greene Place, there are six divergent sub-tracks and four island platforms for the express and baggage service and one track for the service of a row of meat houses along Fort Greene Place. The remaining corner of the site is occupied by the heating and mechanical plant. The depressed structure is enclosed on all sides by a massive concrete wall and the platforms are of concrete with granolithic finish. Drainage is provided by agricultural tile drains, along tracks, delivering to a sump, at which will be installed an electric pump.

The roof or deck over the depressed portion will carry a separate structure for the passenger station, post office, express station and for the elevated railroad station, the latter being utilized in the first story as a station and office for merchandise freight which will be handled by nine large elevators to the second story, three similar elevators being also installed in the express station. The deck between and around the buildings will be paved so as to form practically a continuation of the street surface and will afford driveways up to 70 ft. in width between and around the buildings. The second story of the elevated railroad station will provide three covered platforms from 400 to 480 ft. in length for the service of five stub tracks besides which there will be four storage tracks. Connections will also be made at this level for two tracks with those of the Brooklyn Rapid Transit Elevated Railroad on Flatbush Ave. with the existing station adjacent to the new terminal passenger station.


Excavating, Concreting and Erecting Steelwork, Concrete Plant in the Foreground

The soil at the site of the terminal is of an irregular character composed on the Atlantic Ave. side, of hard compact drift with many large boulders cemented in the earth and loam so tightly as always to require excavation with a pick. Part of the soil on the opposite side of the terminal is of fine compact sand free from boulders, the remainder of it contains gravel and boulders to a depth of 12 to 22 ft. below which is clean, sharp sand. The surface being well above high tide level the soil is dry and no difficulty was encountered with water except from the surface or from sewers and pipes.

The contract for the substructure for the terminal included about 160,000 cu. yd. of excavation, 16,000 yd. of concrete, and 1,500 tons of structural steel, but has since been extended to more than double the original amount by the change of plans and by the decision of the Railroad Company to cover the entire area of the depressed yards, thus involving the addition of about 1,500 tons more of steel. The work comprised in the original contract is now practically finished and the work on the extensions of it and in the depression of the adjacent freight yard will probably be completed in about a year.

The contractors were required to assure the safety of adjacent buildings and of the elevated railroad structure and to maintain uninterrupted service on the passenger tracks entering the terminal on Atlantic Ave. and for the freight track serving the meat houses. Operations were commenced at a point in Atlantic Ave. midway between its intersections with Flatbush and Fifth Ave. A pit was started here and from it an excavation about 15 ft. deep and 60 ft. wide extending from curb to curb was carried simultaneously in both directions for a total length of about 400 ft. The excavation was made by pick and shovel, work being carried on at two full height transverse breasts, and the spoil being hoisted in steel 1-yd. buckets by derricks seated on top of the breast and moving backwards as the excavation progressed. The buckets were dumped into 30-yd. Rogers ballast cars hauled by locomotives on a standard gauge track adjacent to the side of the excavation. The cars were at first removed by the contractors who unloaded them with a Lidgerwood plough to make a fill at New Lots, afterwards the spoil was removed by the Long Island Railroad Company.

This excavation extended to the south line of terminal where part of it was bounded by a heavy concrete retaining wall previously built by the railroad company. The rest of this side was sheeted with 3-in. square edged planks. On the opposite side of the trench the earth was sloped up to the surface at about 60 deg. so as to avoid undermining the outer row of elevated railroad columns in Atlantic Ave. At the west end of the trench the derrick was moved transversely to the sidewalk and returned parallel with its former movement handling the material excavated to enlarge the trench to a total width of 70 ft. This portion of the pit was only excavated to a depth of about 10 ft. in order not to go below the old foundations of the elevated railroad columns. Pits from 8 to 12 ft. square were sheeted down 12 or 18 ft. farther and in them were built in forms the offset concrete piers for the steel columns carrying the street level deck. The steel columns and girders were delivered by cars on the Atlantic Ave. surface track under the elevated railroad and were unloaded by the steam derrick which had handled the excavation at that end of the trench. They were erected with a jinniwink derrick operated by hand and moving on top of the assembled beams and girders.

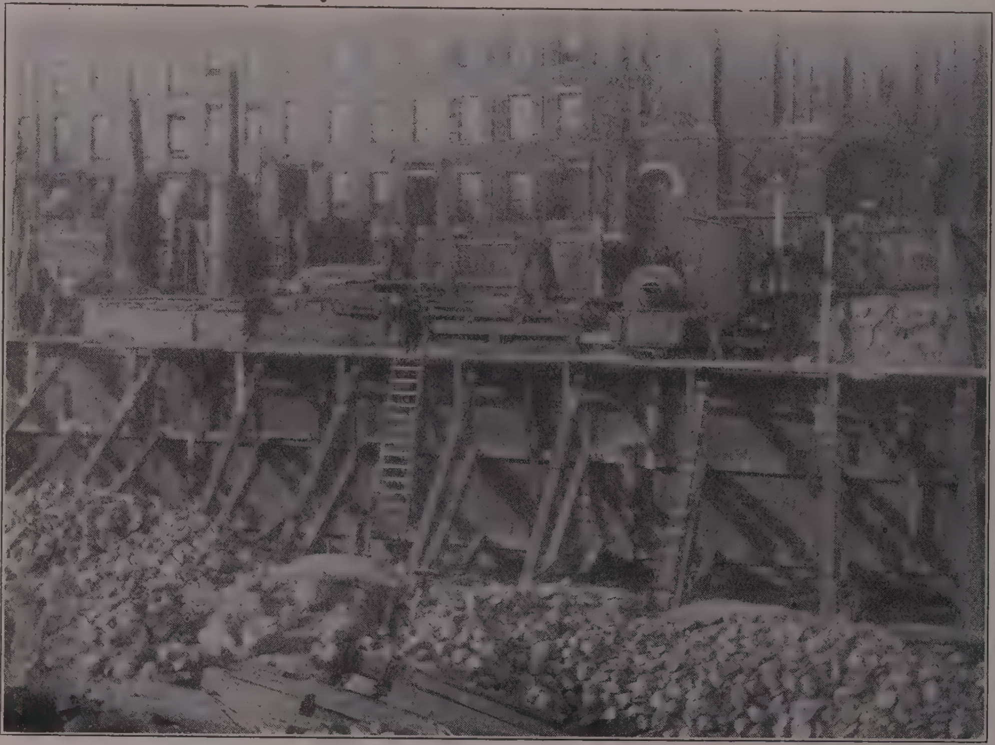
In order to provide for the underpinning of the elevated railroad columns two sheeted pits each about 6 ft. square and 12 ft. deep were dug about 18 ft. apart in the clear on opposite sides of each column. In each of them timber cribbing was built up nearly to the original surface of the ground and on the cribbing was placed a set of six 24-in. I-beams, three on each side of the column. A 14x14-in. transverse timber was supported on the top flanges of these beams on each side of and close to the elevated railroad column. Alternate rivets in the flanges of the H-shape column were cut out and through the holes thus left, long horizontal ¾-in. bolts were placed which passed through the column and projecting beyond each web engaged on each side a 12x12-in. vertical timber about 12 ft. long. These bolts being tightly screwed against bearing washers on the outer face of the timbers held them very close against the column faces and thus developed enormous friction there. The lower ends of the timbers were wedged against the upper surface of the 14x14-in. transverse timbers and thus transferred the column loads through them and the steel girders to the cribbing. The earth was then excavated between the cribs, the old column piers removed and new ones carried down below sub-grade. In some cases the friction pieces on the faces of the columns were omitted and the elevated structure was supported by heavy timber trestles seated across the top flanges of the 24-in. I-beams and wedged up against the lower flanges of the elevated railroad girders so as to carry the structure directly, the elevated columns being suspended from their girders.

Meantime the passenger traffic was carried on trestle falsework seated in the bottom of the trench and preparations were continued for completing the steel deck beyond the line of the elevated railroad. A portion of it was made with long span steel girders supported partly on the concrete retaining wall already mentioned and partly on columns on the opposite side of Atlantic Ave. These columns are seated on a continuous longitudinal footing wall, and the latter was built in a sheeted trench about 8 ft. wide so as to permit the erection of the steel work before the excavation was completed. Some of the elevated railroad columns were carried on new independent footings and others were supported by the new steel substructure of the terminal. When it happened that the location of the elevated columns coincided with those in the terminal, the latter were made double and received the former on their caps at street level. In other cases the elevated columns were carried on transverse beams or diaphragms connecting the webs of deep twin girders about 4 ft. apart which in turn were carried by special twin columns of the terminal substructure. In both cases the bases of the elevated columns and the supporting steel work were enclosed in a mass of solid concrete. As soon as the steel and concrete arch deck of the terminal substructure was completed the passenger tracks were transferred to it and the falsework trestles removed. Later the subway connection was opened at the east end of the terminal and the passenger tracks entered at low level and were served by temporary platforms communicating by stairs with a temporary frame building waiting room constructed on the deck, which enabled the old passenger station to be removed.

After the steel work was erected as above described 24-in gauge service tracks were laid, as required in the bottom of the excavation, and the remainder of the earth was excavated by hand to sub-grade, care being taken to save the boulders to be crushed for concrete. The remainder of the spoil was shoveled into steel buckets and taken on cars to convenient points where temporary openings had been left in the roof through which they were hoisted by derricks and emptied into the 30-yd. dump cars on tracks carried over the steel roof.

On the Fort Greene Place side of the terminal the 320-ft. row of existing brick meat houses, two and three stories high, had cellars and footings about 10 ft. below the surface of the street. These meat houses, which in the old terminal yard were served by the track at street level in the rear of the buildings, will be provided for in the reconstructed terminal by a track in the depressed yard, about under the old surface track. Each meat house will then have an elevator on the outside of the underpinning wall by which the meat will be raised to the street level. The excavation here extends to the rear walls of the house and is about 22 ft. deep, thus making it necessary to underpin the walls. A 10-ft. excavation was first made on this side of the terminal, and as it progressed the track serving the meat houses and about 25 ft. distant from their rear ends, was carried on falsework trestles seated i nthe bottom of the pit, thus maintaining the freight service to the meat houses. A trench 20 ft. wide and 10 ft. deep was opened between this track and the meat houses, and in it needle beams were placed through the rear walls of the houses. Another trench about 10 ft. wide and 10 ft. deep was then sheeted down under the walls of the houses, and in it was built a heavy retaining wall to enclose that side of the terminal, also to serve as a new foundation for the rear walls of the meat houses.

About two months after the commencement of the work excavation was started on the Hanson Place side of the terminal which was sheeted down to sub-grade and braced by inclined shores as the earth was dug by hand and shoveled into one-yard Stuebner steel automatic dump buckets. These were delivered by cars on 24-in. tracks laid in the bottom of the pit to derricks which emptied them into the 30-yd. cars at street level. Along the street line forms were built of 2-in. horizontal planks with heavy vertical pieces braced by one tier of 45-deg. inclined posts to the bottom of the pit, and by wedging against the sheet piling. In them was built in 50-ft. lengths the concrete retaining wall with a battered retaining wall of a maximum height of 30 ft. and width of 14 ft. at the base. The ends of each section were offset in 6-ft. steps enclosed by vertical transverse bulkheads, and expansoion joints were provided 30 ft. apart. These joints were in reality special sections of the continuous wall weakened so as to locate fracture at these points if it should occur anywhere through expansion and contraction. They were made by forming vertical holes in the wall from footing to coping. These holes were made with square cores 4 ft. long, tapering from 5 in. to 6 in., which were set with their diagonals 3 in. apart in the clear on a transverse line and were gradually pulled up as the concreting progressed. Concrete made 1:3:5 with Giant Portland cement and a mixture of two parts of gravel with three of broken stone was mixed wet in two Ransome mixers and in two Smith concrete mixers, one of which was operated by a General Electric motor. The concrete machines were located on platforms about 5 ft. above the tops of the moulds and delivered to 1-yd. end or side dump cars running on 24-in. tracks supported on the moulds.


Concrete Mixer Set on Braced Sheeting

Concrete for the floors and jack arches of the roof was mixed by the sand machines which were occasionally moved as the work progressed. The concrete was delivered from the machines to the work in 1-yd. buckets carried on 24-in. gauge cars with tracks on the bottom of the pit or on the top of the steel work as was most convenient.

An important feature of the concrete work was the application to the floor, walls and roof of the Hydrex waterproofing. The concrete in the upper surface of the jack arches was carefully smoothed and coated with a specially made hot pitch to form a yielding joint between the concrete and the waterproofing. After the pitch was cooled it was covered with three succesive layers of Hydrex waterproofing felt laid in hot pitch and finally protected with 1 inch of cement mortar covered with a single course of red bricks laid flat and plastered with cement mortar. After this application was finished for the subway roof the latter was backfilled, tracks laid over it and the track traffic resumed.

About 50,000 yd. of the excavation was accomplished by machinery, but as it was impossible at first to secure an entrance for spoil cars into the bottom of the pit the work was commenced by hand, as already explained. After the excavation had been commenced on the Hanson Place side a Thew automatic steam shovel with a $1\frac{1}{2}$-yd. bucket was brought over the completed steel roof on the north side of the terminal and was lowered down a 30-deg. incline to the bottom of the pit on the west side. It started digging a trench eastwardly parallel with and north of Atlantic Ave., the spoil being delivered by the steam shovel to $1\frac{1}{2}$-yd. buckets hoisted by an overhead derrick and dumped into the large cars on the surface. Simultaneously a Lancaster excavating machine with a $1\frac{1}{2}$-yd. orange peel bucket was operated farther east, digging a trench in the same line as the steam shovel so as to open communication as soon as possible with the subway tracks at the east end of the terminal. This machine delivered its spoil directly to the 30-yd. cars at street level andexpedited the opening of the trench, which was immediately utilized for a loading track for spoil cars backed in from the subway. The steam shovel made a maximum record of 1,200 yd. in 10 hrs. Besides the plant already mentioned there was installed an Ingersoll-Sergeant compressor to furnish air for the Chicago Pneumatic Tool Company's riveting hammers, and a 10x16-in. stone crusher built by Julian Scholl, which had a capacity of about 60 yd. of 1½-in. broken stone in 10 hrs. and was operated by an independent horizontal engine. Steam for the different machines was provided by separate boilers located in convenient places. The work was executed by an average force of about 350 men working one 10-hour shift daily.

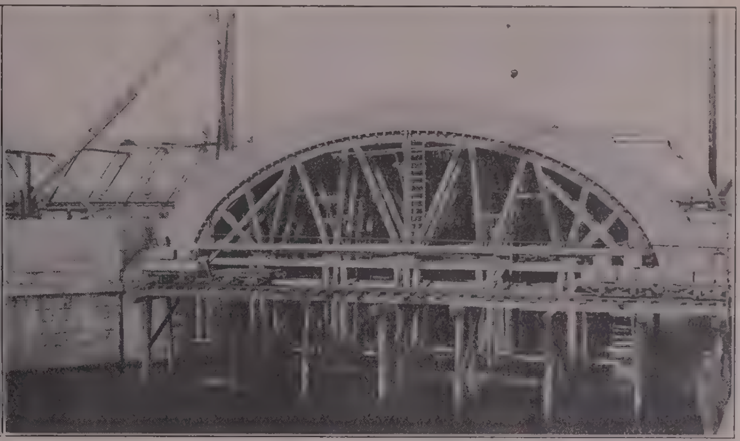
The terminal has been designed and its construction supervised under the direction of Mr. J. V. Davies, chief engineer, and Mr. George Sargeant, Jr., principal assistant engineer, who was recently succeeded by Mr. L. J. Carmalt. The work is being executed by the Degnon Contracting Company, N. Y., Mr. F. D. Fisher, engineer.

An Unusual Bridge, 75 ft. long and 67 ft. wide, is now in course of construction at New Haven, Conn., from the designs of City Engineer Cassius W. Kelly. It is divided into three spans by bents of reinforced concrete columns capped with beams of the same material. These beams and the abutments carry I-beam stringers 5 ft. apart which support a 6-in. concrete floor, reinforced in the bottom with Kahn bars and in the top with twisted rods. This concrete floor carries a vitrified brick pavement. The work is being done by the Russell Contracting Co., of New York.

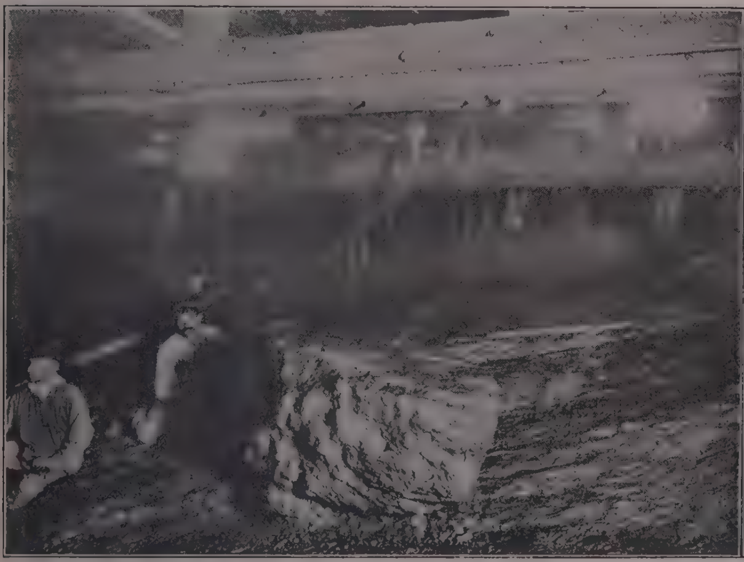
Construction Methods at the Stone Bridge at Hartford, Conn.

A handsome and imposing stone bridge across the Connecticut River forms an important portion of the $2,500,000 improvements now being made the Connecticut River Bridge and Highway District of Hartford. The bridge is built entirely of granite from the Leete's Island and the Stony Creek quarries, and has a total length of 1,185 ft., a width of 82 ft. over all and will accommodate electric cars, highway traffic and pedestrians. It contains eight semi-elliptical arches with spans varying from 119 ft. to 68 ft., the shortest spans being at the ends of the bridge and the increasing rises for the longer spans being successively arranged to provide for a continuous parabolic camber, giving the roadway a maximum height of about 50 ft. above low water.

First Three Arches Completed.



Falsework, Centering and Service Track



Large Boulder in Caisson, Blow-Out Pipe in Background

Laying Out Templates

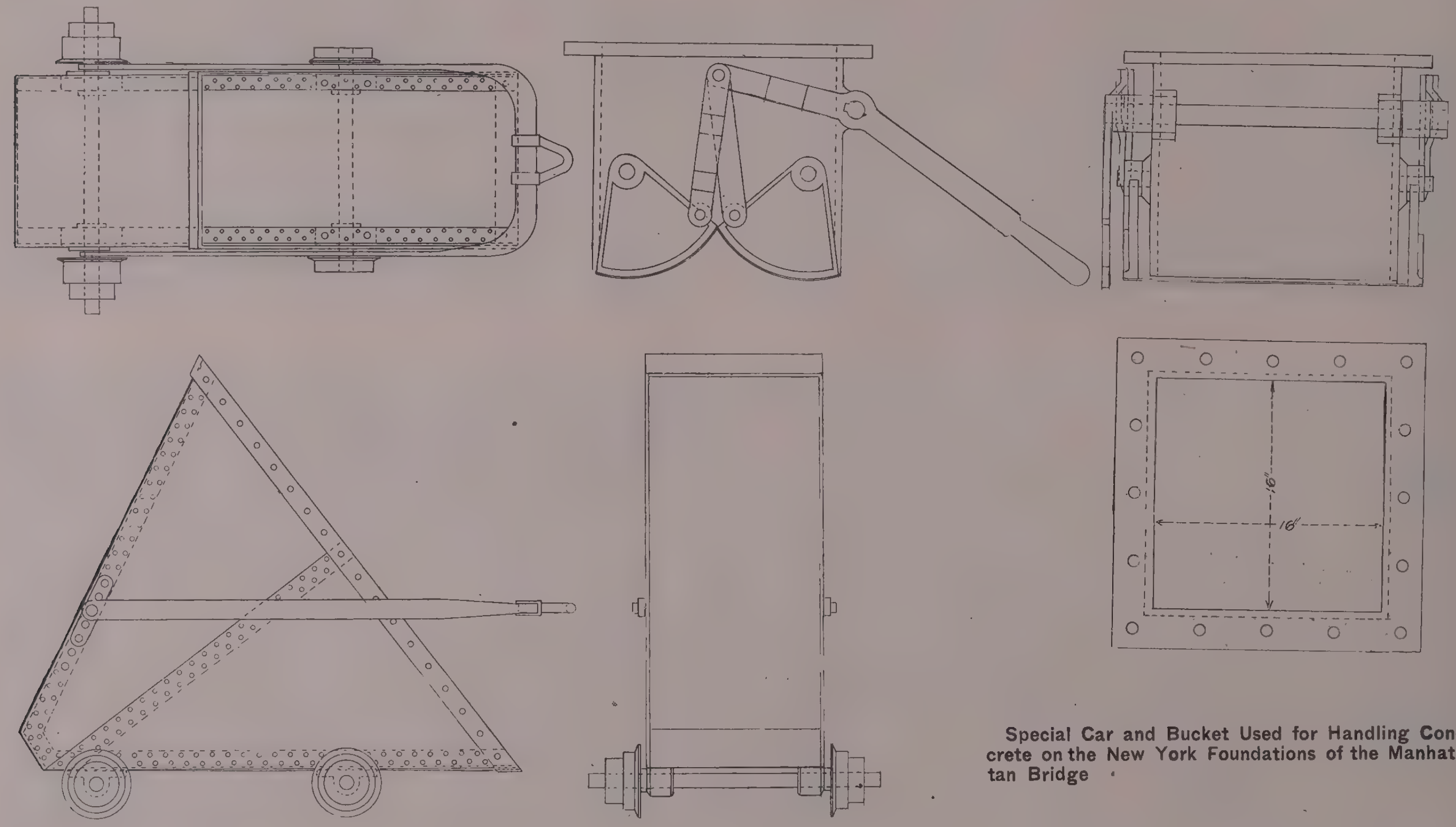
All of the original plans provided at one end of the bridge a Scherzer rolling lift span with two leaves made with segmental plate girder ribs harmonizing in their outlines with the arches, as indicated in the sketch published in The Engineering Record of December 26, 1903. This was in accordance with the original requirements of the United States Government engineers, but eventually it was concluded that the draw span was not indispensable and its omission has enabled the bridge to be constructed entirely with stone arches, thus contributing to its improved appearance. The piers are at right angles to the bridge axis and have a width corresponding to the lengths of the adjacent spans and varying from 16 to 40 ft. All of them have wooden pneumatic caisson foundations sunk to a depth of about 50 ft. to bearing on a brown stone stratum.

The work is of unusual interest on account of the attractive design, the excellence of construction, the great care taken in detailing and supervision, the installation of a very complete and efficient plant and for some of the construction methods. The large timber caissons for the pier foundations have 12-in. walls and 36-in. decks of solid yellow pine timber and are made integral with the permanent portions of the coffer dams. They were successively built on a large pontoon, the two halves of which were afterwards separated on the center longitudinal line allowing the caissons to sink between them until they floated independently and were towed to position. The caissons were sunk by the aid of attendant scows and boats which provided the materials and on which were installed derricks, concrete plant, boilers, pumps, etc., as described in The Engineering Record of December 31, 1904. A complete plant was established by the contractor on shore and equipped with a power station, large Ingersoll-Sergeant air compressors, a number of exceptionally large and powerful guyed derricks and other ordinary plant. A special feature was the establishment at the site of a complete stone-cutting yard including a covered building supplied with a traveling crane and equipped with a system of pneumatic stone-cutting machinery.

The brown stone stratum to which the pier foundations are carried was found to be bonded in layers pitching slightly toward the east. The layers were generally quite thin and were dressed to form steps in the working chambers in the caissons which provided an excellent bed for the concrete and secured very good hold for the piers. In some places the rock when exposed showed small grooves usually running northeast and southwest, the surface being worn smooth by glacial action. Under the west abutment the stratum was of a peculiar formation with veins of very hard blue rock running northeast and southwest. These veins were in approximately vertical planes and were very distinctly defined in the brown stone with which in some instances they gradually merged. Most of them were very narrow, from a small fraction of an inch to 3 or 4 in. wide. In one instance a vein that was apparently quartz ran through the blue stone across nearly the full width of the caisson.

The pneumatic foundations are now entirely completed and the three arches at the east end of the bridge shown in the accompanying photograph have since been finished and their centers removed. During the construction of the piers a large boulder was encountered in the 46x131-ft. caisson, and as it was sound and solid it was determined not to blast and remove it, but to leave it in position, thus forming a sort of cyclopean filling in the regular concrete footing. The bed rock was carefully cleaned, as shown in the picture, and the boulder was also washed with brooms and a strong hydraulic jet after which the water used for this purpose was ejected through the rubber blow-out pipe shown in the background. The boulder was carefully bedded in concrete, and concrete was thoroughly packed around it during the filling of the caisson.

Great pains were taken by the engineer corps to provide abundance of accurate detail drawings and to systematize the operations so that records should be available for all important points. Each stone is shown in detail on separate planes and each has a reference mark corresponding with the drawings which indicate at a glance its position in the bridge. The courses in the piers and abutments are lettered from the bottom up and each stone in every course is numbered. The piers are numbered from end to end and the arches are similarly numbered in the same direction, the stones in each row being lettered, commencing from the down stream side. The arch rings and ring stones were laid out full size on the unobstructed floor of a large loft secured for the purpose. On it were screwed down planed boards forming a rectangle large enough to enclose the largest arch and providing a permanent point from which longitudinal and transverse center lines were drawn for axes from which the points in the elliptical intradoses of the different spans were determined by means of ordinates 1 ft. apart laid out from marks located in the axes by lines intersecting on the heads of copper nails. The points in the curves were connected by thin strips of pine coincident with them which were sprung to make a smooth curve adjusted to the exact line of the intrados and lightly nailed to the floor, as shown in the accompanying photograph where the curved strip is in position for a small arch and outside of it an ordinary template, made by the contractors, is shown in position for the lagging of an arch of longer span.



Special Car and Bucket Used for Handling Concrete on the New York Foundations of the Manhattan Bridge

After the curves of the intrados had been fixed it was easy to divide it into the required spacing for the radial joints and to mark the latter on it at right angles. When this was done the joints between the voussoirs and the complete vertical elevations of these stones were marked on the floor and templates made from sheet zinc were cut to conform with them and fitted to position, as is also shown in the picture where they are marked with their reference numbers and letters. This method of making the templates insured great confidence and was found very satisfactory. The details of cutting the templates were described in our previous article.

The arches were built on centering made with several thicknesses of plank bolted together and accurately dressed to a curve parallel with that of the intrados as determined by the template already mentioned. They were braced at intervals of a few feet by inclined posts converging to the caps of several timber bents on falsework piles driven between the piers, as indicated in the photographs. The centers were spaced about 6½ ft. apart and carried narrow lagging strips parallel with the axis of the arch, on which the stones were seated. The ends of the centers were connected by horizontal sills or ties, and they were supported from the corresponding longitudinal pile caps by sets of oak wedges which were driven out in the usual manner to strike the centers which did not cause a settlement of more than 1/16 of an inch.

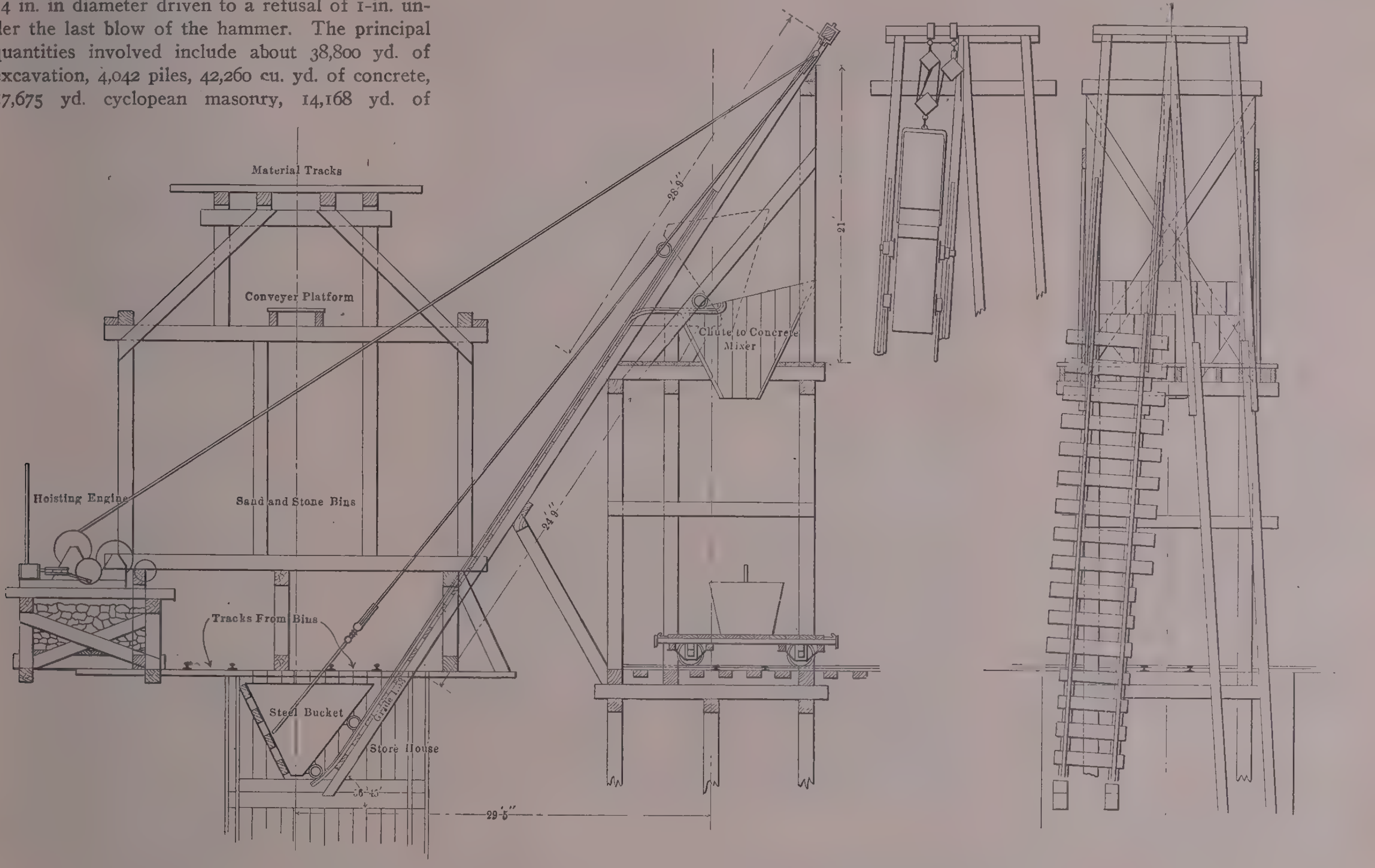
Materials were delivered to the arches on small four-wheel cars on a service track carried parallel with and close to one side of the bridge. They were handled by boom derricks seated on each of the piers and thus easily commanding the whole area of each span. All of the arch stones were very carefully washed when put in place and alternate ones were made longer than those adjacent to them and the spaces thus left were filled solid with 1:2:4 concrete leveled up to the tops of the headers. The radial joints between the voussoirs are ⅜-in. thick and are accurately determined by kiln-dried oak wedges driven between them at each corner and removed before the mortar set. When the keystones were set completing the arches, they were found to fit within 3/16 in. and consequently required no cutting.

Mr. Edwin D. Graves is the chief engineer, Mr. Alfred P. Boller, consulting engineer, and Mr. Edmund M. Wheelright, consulting architect of the bridge. Messrs. McMullen, Weand & McDermott of New York, are the contractors for the work.

The Water Turbines of the municipal power station of Sofia, Bulgaria, are of 500 h.-p. when running at 400 r.p.m. with about 32 cu. ft. of water per second under a head of 175 ft. The penstock ends in a manifold from which a branch is taken to feed each turbine, this branch rising to the floor above and entering the end of a radial outside discharge wheel with horizontal axis. It will be noticed that this arrangement does not utilize all the fall of the water, owing to the upward turn of the turbine branches, which is counterbalanced to some extent by special care in the design of the draft tubes. Each turbine has a flywheel and is direct connected to the generator by a flexible insulating coupling.

EXCAVATING AND CONCRETING THE NEW YORK ANCHORAGE OF THE MANHATTAN BRIDGE.

The New York anchor pier for the Manhattan Bridge across the East River, which is between the Brooklyn bridge and the Williamsburg bridge, and is officially known as bridge No. 3, is substantially like the Brooklyn anchorage pier, which was described and illustrated in The Engineering Record of December 17, 1904. It is notable for being one of the largest structures of its kind in the world. It varies but slightly from the Brooklyn pier in dimensions and in the number and arrangement of piles in its foundations. It will be about 182 ft. wide, 237 ft. long and 160 ft. high, pierced with a large transverse archway for the passage of a street, and is to contain a number of spaces chambered out of the masonry so as to avoid unnecessary mass and concentrate the weight where it will be most effective. The foundation piles are 27 to 35 ft. long and at least 14 in. in diameter driven to a refusal of 1-in. under the last blow of the hammer. The principal quantities involved include about 38,800 yd. of excavation, 4,042 piles, 42,260 cu. yd. of concrete, 57,675 yd. cyclopean masonry, 14,168 yd. of granite facing and 7,063 sq. yd. of paving. The contract price of the work is $1,197,000 and the specifications require that it shall be completed in 450 days, commencing July 15, 1905.



Arrangement of Inclined Hoist at the New York Anchorage of the Manhattan Bridge

The bottom of the pit is at elevation — 12 at the river side and the average depth of excavation is about 22 ft., the piles being cut off at elevation —10. The soil consists generally of about 10 ft. of fill, 4 ft. of muck and then a deep bed of sharp, fine sand containing a little loam and some coarse sand. It has many deep pockets several feet in diameter, of quicksand, and there were found in its excavation many remains of timber and masonry cribs and foundations and various interesting relics.

A very complete plant was installed at the outset for excavating and handling the earth and sand and for receiving and storing materials, mixing concrete, putting it in place and laying the stone masonry. A double-track timber trestle viaduct with a total length of about 1,500 ft. extends west from the tower pier across an existing dock and through the street in an approximately straight line about 1,000 ft. to the shore end of the anchorage to which it is parallel on the north side and from which it is only a few feet distant. The trestle continues around the west and south sides of the anchorage so as to form a U, enclosing it on three sides.

All spoil is removed and all materials are delivered on this trestle. It has two standard gauge tracks rising to a summit on the main line near the shore end of the anchorage where the grade is about 35 ft. above the street. The tracks descend both ways at a maximum grade of 3:100, reaching the ground at the end of the trestle on the s. w. corner of the anchorage, and having an elevation of about 15 ft. above the dock at the tower pier. The trestle has framed bents of 12 x 12-in. timber very strongly braced so as to make an unusually rigid structure. It is of special design having provision made between the two tracks and just below them for a 24-in. Robins conveying belt, manufactured by the Diamond Rubber Co., Akron, O. It is notable for its great length of 1,000 ft. on centers which reaches from near the shore end of the anchorage to the east end of the viaduct and beyond, across the top of the anchor tower, and is said to be longer than any similar belt before installed. In general the tracks are carried on wooden stringers, and the trestle bents are spaced about 15 ft. apart between the anchorage and the bulkhead line. Some of the bents are spaced much farther apart to clear the street and to provide more room underneath them. These spaces are spanned by lattice girders from 45 to 60 ft. long previously used for the Brooklyn Elevated Railroad structure.

The excavation was made with pick and shovel and by 1½-yd. Hayward buckets of both the orange peel and clam shell types, operated by five derricks with booms about 90 ft. long. They were on towers located just outside the limits of the excavation, one near each corner and one in the middle of the west or shore side. Each has a capacity of about 16 tons and together they command the entire area of the anchorage. Each is rigged with six ⅞-in. steel guys and with four-part topping and hoisting tackles of ⅝-in. plough steel rope, and has swinging gear, all operated by hoisting engines having three drums and two spools each, manufactured by the National Hoisting Engine Company. These derricks operated the excavating buckets and delivered the spoil to eight 2½-yd. side dump cars made by H. J. McCoy. The maximum rate of excavation was 800 cu. yd. in 10 hours. The dump cars were hauled to the summit of the viaduct by a 3½-in. steel cable 1,600 ft. long on each track. Each cable passed over a sheave at the summit and thence down to a two-drum engine made by the National Hoisting Engine Company, Newark, N. J. From the summit the dump cars in trains of three descend by gravity to the river end of the viaduct, being controlled by the cable which was operated by a brake. The cars are pulled back to the summit by the hoisting engine and thence descend to the required position alongside the anchorage pit by gravity. Near the river end of the viaduct the cars dump on an inclined cantilever apron to dump scows.

Before commencing the excavation the pit was enclosed on all sides by 12-in. sheet piles from 12 to 20 in. wide, which were grooved and splined and driven to — 26 by a Vulcan steam hammer, sometimes asisted with a water jet. They were driven between two double rows of waling pieces which were bolted to a double row of outside bearing piles.

The anchorage piers cut off a 90x20-ft. triangular section from the end of the seven-story brick factory and warehouse building occupied by the Keating Pipe Company. This portion of the building was vacated and the floors were shored up from story to story by lines of interior vertical posts and sills in the undisturbed portion of the building. The condemned portion of the building was removed and a pile foundation was driven just outside the limits of the anchorage, a new wall was built on it to receive the ends of the floor beams and the building was thus assured against undermining before excavation was commenced.

The foundation piles were driven without water jets by four drop machines having 3,500-lb. hammers in 45-ft. leads and by one 5-ton steam hammer and one 4-ton steam hammer. They were driven to a refusal of 1 in. at the rate of about 16 piles in 10 hr. for each machine. A moderate quantity of water was encountered and has been removed at a maximum rate of about 2,500 gal. per minute by an 8-in. Sturtevant pump. Another centrifugal pump made by the Morris Machine Works has also been installed for emergency, but it has not been found necessary to operate them both together.

Besides the derricks serving the anchorage pit there is one derrick in the adjacent storage yard which has a 60-ft. boom, one on the tower foundation, and one on the dock near it, both with 45-ft. booms, and another on the shore near the bulkhead line, all of them being stiff-leg derricks operated by National hoisting engines.

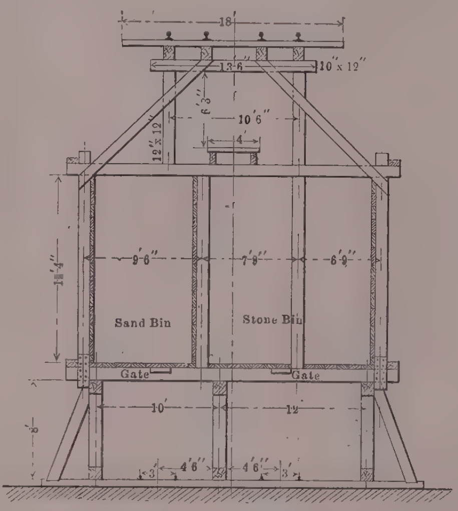
The derrick on the tower pier is equipped with a 1½-yd. clam shell bucket with which it unloads coal, sand and broken stone from barges moored to the pier and places them in a 6-yd. elevated bin with a hopper bottom which is located near the center of the pier. A horizontal sliding gate in the bottom of the hopper delivers through a short chute to the conveyor belt by which the materials are carried nearly to the shore end of the anchorage where a tripper is arranged to dump them in any required place. The coal is delivered at the rate of 300 tons in 10 hrs. and is dumped to a storage bin on the ground under the viaduct and the broken stone and sand are dumped into storage bins between the viaduct trestles which have capacities of 700 and 525 cu. yd. each respectively. Bags of cement are also sometimes delivered by hand to the river end of the belt and transported by it to the cement storage house at the shore end of the anchorage, but it has been more convenient generally to load them on skips and haul the latter on cable-cars. The storage house has a capacity of 18,000 bags of cement which are delivered to it by a chute through the roof at the rate of 3,500 bags in 10 hr.

The horizontal bottoms of the sand and stone bins are elevated about 6 ft. clear of the mixing platform on which there are two parallel lines of 3-ft. track. One line is under the center of the two sand bins and the other is under the center of the two stone bins. Each bin has in the bottom a controlling gate through which its contents are delivered to measuring cars on these tracks. The gate has a rectangular cast iron frame with the bottom closed by two pivoted segments of cylindrical surfaces which can be easily revolved to open or close by the links and levers shown in the accompanying detail. Pipes in these bins are supplied by exhaust steam to heat the sand and stone in cold weather.

The standard stone measuring steel dump car has a capacity of 60 cu. ft. and is made with the bottom inclined at an angle of 30 deg. from the horizontal. The discharge is through a chute in front which is closed by a gate swinging on a horizontal axis at the upper edge and operated by a lever from either side or from the rear. The standard steel sand measuring car is of a different type and has a capacity of 30 cu. ft. Its bottom is inclined at an angle of 50 deg. and the contents are discharged through a chute on one side which is closed by a vertical sliding gate, the latter being commanded by a lever from the end of the car.

The sand and stone bins are arranged side by side, the two pairs being about 50 ft. apart in the clear on opposite sides of an inclined hoist. Each bin has a separate measuring car which is simultaneonsly filled and pushed by hand to the center of the space between the bins where its contents are dumped to the charging cars, two of which, for alternate use, are installed on an inclined track at right angles to the tracks for the measuring car.

Each steel charging car has a capacity of 94 cu. ft. and is of special construction designed to conform to the angle of the incline and maintain the upper edge of the car horizontal. The rear wheels have double treads one set in the plane of the front wheel tread and the other set outside of it. Both front and rear wheels engage the inner rails of the incline and maintain the car in position during its ascent. When the car reaches the top of the incline the forward wheels pass over the ends of the rails and the outer treads of the rear wheels engage the auxiliary rails of a wide-gauge extension to the track and elevate the rear of the bucket so as to discharge its contents into the hopper of the concrete mixing machine. All of these cars and the controlling gates were manufactured by the G. L. Stuebner Iron Works, Long Island City, N. Y.

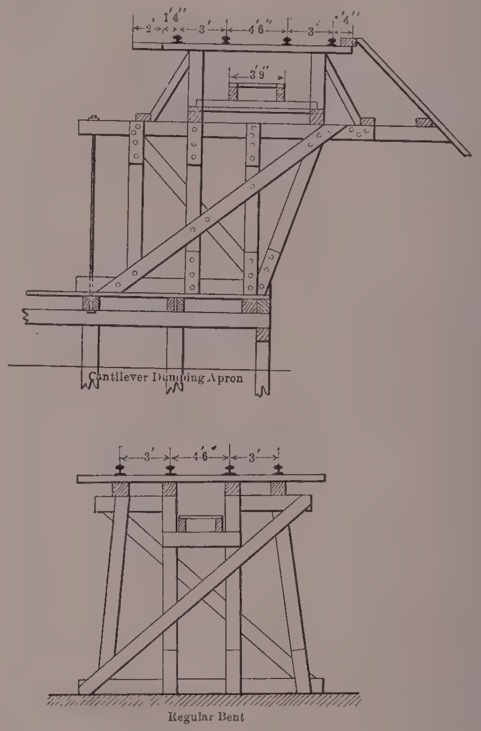


End Bent, Storage Bins

The measuring cars are simultaneously filled with sand and broken stone from one pair of storage bins and are pushed by hand to the edge of a well at the foot of the incline. Their contents are discharged by gravity into one of the charging cars while it is in the well at the foot of the incline with its upper surface just below the level of the platform. Alpha Portland cement is delivered from the store house in wheelbarrows and is emptied by hand into the charging car with the sand and stone in proportions of 12, 24½ and 49 cu. ft. for each batch. The charging car is drawn to the top of the incline by a Lidgerwood hoisting engine, and is automatically dumped into a hopper connecting with the Carlin 3-yd. cubical concrete mixer. Water, and in cold weather, live steam, is admitted through the hollow trunnion according to the judgment of the operator; the machine is revolved 10 or 15 counted times and the concrete is discharged into Stuebner excelsior bottom-dump steel buckets of 63 cu. ft. capacity.

The buckets are delivered by flat cars running on narrow-gauge elevated tracks along the north side of the anchorage pit and to several spurs at right angles to it. They are taken to the different derricks and emptied by them as required. Eight of these buckets are provided and have been used very satisfactorily for the heavy service involved in handling the excavated materials as well as large masses of stone, brick work, concrete, etc. The installation of duplicate charging buckets enables one bucket to be filled at the foot of the incline while the other is hoisted to the top, and thus allows the concrete mixing machine to be operated almost continuously with the result that as much as 500 cu. yd. of concrete has been laid in 10 hr.

About one-fourth of the concrete in the pier has already been made and it is expected that when the work becomes too high for the derricks, which are seated at elevation +24, they will be replaced by booms mounted on steel towers permanently built into the anchorage masonry somewhat in the manner successfully adopted for the completion of the new Croton dam, as illustrated in this journal July 9, 1904. The concrete mixer is driven by a 25-hp Olney & Warren engine connected to it with a special patent sprocket chain made with malleable iron hook links. The chain engages a sprocket collar bolted in halves to the belt clutch with which the machine was originally equipped.



Cantilever Dumping Apron

Regular Bent

Trestle Bents on Docks

The pile drivers have individual boilers and produce their own steam; all other steam used for pumps, engines, and other purposes on this work is generated in a battery of three 100-h.-p. locomotive boilers in a house built under the viaduct near its summit, and one 100-h.-p. boiler on the dock. Steam is distributed throughout the plant in about 1,600 ft. of asbestos covered mains from 2½ to 5 in. in diameter.

The work has been designed and is being constructed under the direction of the department of bridges, New York City, Mr. James W. Stevenson, commissioner; Mr. C. M. Ingersol, chief engineer; Mr. O. F. Nichols, and Mr. R. S. Buck, consulting engineers; Mr. H. D. Robinson, engineer in charge, and Mr. G. G. Lewis, resident engineer. The contract was awarded Feb. 9, 1905, to the Williams Engineering & Contracting Co., Mr. John Williams, President, and Mr. J. P. Heath, engineer, and Mr. William Walsh, master mechanic. The contract provides that the pier below the cables shall be completed in 450 calendar days, and the remainder in 150 calendar days more. The work is now being carried on by an average force of about 100 men working single turn. During the time of excavation the force was increased to 200 men.

William H. Brown.

By Samuel R. Kirkpatrick.

W. H. Brown, who, since June 1, 1881, has been chief engineer of the Pennsylvania Railroad Co., retired on Feb. 28th. During the years he has been with the company he has been instrumental in bringing the system up to the high standard it has reached. He has not only made a name for the railroad, but he has established a reputation for himself which is possessed by few railroad civil engineers. This retirement was not on account of ill health or the inability to continue at work, but was according to the rules of the Pennsylvania R. R. Co., which compel an officer and employee who shall have attained the age of 70 years to be relieved from the service.

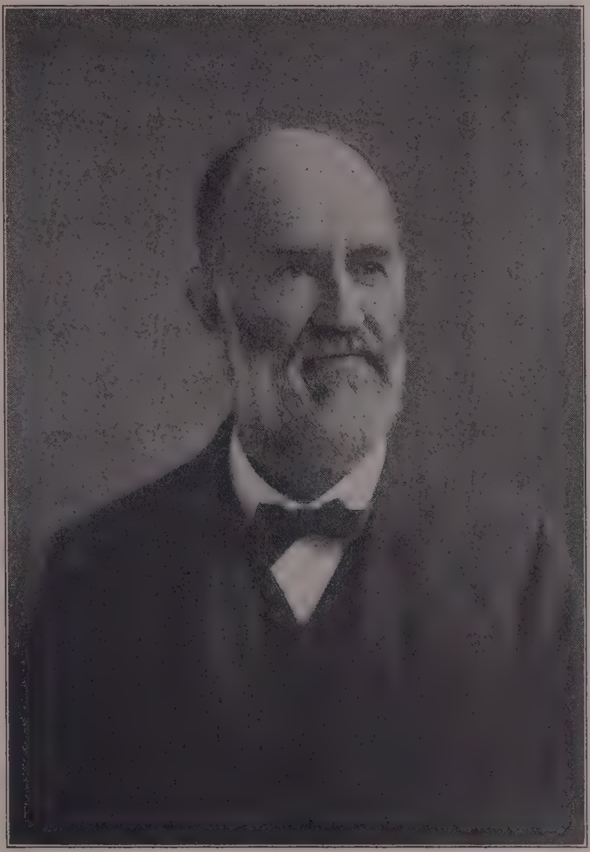
The Pennsylvania R. R., when Mr. Brown entered its service, was nothing more than two long stretches of rails. Since he has been at the head of the engineering department it has greatly developed, and from a tortuous line it is now as straight as a road can be built which runs through such a country as it does. He has seen many changes in the Pennsylvania Railroad Co. since he began his railroad career with it. In keeping with the developing of the line his ideas have also broadened out until he is known the world over as one of the greatest railroad engineers of the country. There are scattered all over the system monuments to his achievements. With the end of this year the Pennsylvania R. R. will be practically a four-track road from Jersey City to Pittsburg. This result was not accomplished without considerable planning on the part of Mr. Brown, who has rarely proved amiss in his conclusions and has had more influence with higher officials of the company than the public has any idea of.

Like nearly all men who have made a name for themselves, Mr. Brown had to work out his own way until he reached the top of the ladder. He always was a tireless worker and never let small things turn him away from what he started out to do. Even when a boy he had a hankering to be a civil engineer and during his leisure hours, which were few, he collected sticks and made axe handles, which he sold to procure books on engineering. This habit, taken up so early in life, has stuck to him. Although he has been in a position to make large sums of money, he has never taken advantage of the opportunities. He has always been the engineer and never the speculator. For years he plodded along without any rest and only gave up when President Roberts sent him away to Cresson to recuperate. Mr. Roberts gave him instructions to take a long rest. But great was the president's surprise to find a report on his desk sent in by Mr. Brown on another route over the Allegheny Mountains. Although this route was not considered then, it has been taken up since, perfected and adopted.

Although Mr. Brown is seventy years of age he has only had seventeen birthdays. He was born in Little Britain Township, Lancaster County, Pa., on Feb. 29, 1836. He was not raised in the lap of luxury and idleness. The early struggles of this great railroad engineer would have deterred many from carrying out their desires. But with him it was different and early in life he decided to win a high place as a civil engineer. The only schooling he had was received in the district public school and later in the Central High School of Philadelphia.

The use of tools of all kinds came natural to him while yet a boy, and at the age of sixteen years he could do carpenter work like a journeyman. When a boy he worked at odd jobs until he secured enough money to buy a second-hand lathe, which was set up in a small house used for storing ashes. His father had purchased a lot of hickory wood for kindling. Young Brown soon turned this kindling into handles for files, chisels, etc., for which he had a ready sale at three cents a piece. This money, with what he subsequently saved from working in the woods of Clearfield County, was used to purchase the most primitive of surveyor's instruments, a Jacob's staff, and with this he made surveys of the neighboring farms, borrowing the deeds to guide him, and gradually acquired a fair knowledge of the work.

Shortly before the war he took up engineering in Philadelphia. He became connected with the Survey Department of Philadelphia and gave the stakes for the first passenger railway in this city, and when the survey was made it attracted considerable interest.



W. H. Brown

Mr. Brown was under Strickland Kneass, who was then chief engineer of the Survey Department. He remained with him until he became associated with Thomas Scott, who had become Assistant Secretary of War. Mr. Scott was very well acquainted with Mr. Kneass and had asked him to send a surveyor to serve under him. He desired to have plans and surveys made of the country on the south side of the Potomac so that he could build a railroad to carry supplies to the Union Army.

At that time the heavy commissary wagons had badly cut up the roads so that it was almost imposible to get the supplies through on time. Mr. Kneass recommended Mr. Brown and he was accordingly sent to Mr. Scott. This, it is believed, was the turning point in Mr. Brown's life, for he gained the good will of Mr. Scott, who quickly saw there was a great future in store for the young engineer, and a year afterwards he began his life work with the Pennsylvania system.

Mr. Brown's connection with the army was an arduous one. He reported to Mr. Scott shortly after the first battle of Bull Run, when the Union Army was driven back to the high ground, and for a time things looked black for the troops north of Washington. There were no correct maps of the country and the army was at a loss concerning it. However in Mr. Scott the Government had an officer who was of sterling qualities and who was capable of getting the best out of all who were under him. Mr. Brown was ordered to go to Alexandria. At this place he was assigned to a room over a sand house where he was locked in and no one could reach him. This precaution was taken to prevent any one from seeing what he was doing and from stealing the plans.

In time they were completed and sent to Mr. Scott, who then found that he had secured something more than a draughtsman. He found that he had an engineer of no mean ability and it did not take him long to bring the latent power out of Mr. Brown.

About this time, General McClellan, who had been appointed chief of the Army of the Potomac, moved his force down to Yorktown. Mr. Brown was placed in charge of the Orange, Alexandria & Manassas Gap R. R. It was on this work that records were made in the construction of bridges and the rebuilding of the railroad. The whole line was practically rebuilt, and twice in one summer he built all the bridges on the line, they having been destroyed by the Confederate Army. He was not daunted by the destruction of his work, for he organized a force of Pennsylvania R. R. carpenters and rebuilt the bridges clear through to Strassburg, which at that time was General Banks' headquarters. During the work of putting the railroad in shape he was never molested, although Mosby Guerillas were often within reach of his men. He often worked ten miles outside of the picket lines until the last bridge was finished.

At Fort Royal, over the Shenandoah River, where the First Maryland Regiment of Union troops were stationed at one time, the bridge was completed at 9 o'clock in the morning and at noon the regiment was driven back and the bridge carpenters who built the structure were set to work to destroy it. At 2 o'clock the same afternoon the bridge was set afire and that night Mr. Brown and his force, along with the Union troops, were driven back to Martinsburg. Later Mr. Brown and his carpenters went to Alexandria, where he reorganized his corps and started in to build the bridges over again.

Among some of the achievements of Mr. Brown while working for the army were the building of the bridge over the Hedgesman River, in order to relieve Siegel's Corps, and a long trestle over the Rappahannock River, constructed in four days, to enable General Pope's army to be supplied promptly with munitions of war and rations.

In 1862 Mr. Brown was taken ill with typhoid fever and was sent home. After he recovered he remained with the army one month, when Mr. Scott sent him to the Pan Handle R. R. as assistant engineer, the line then being finished between Pittsburg and Steubenville. This was in October, 1862. This was Mr. Brown's beginning with the railroad which has made his name famous. He remained as assistant engineer of the Pittsburg, Cincinnati, Chicago & St. Louis Ry.

until 1863, when he was promoted to principal assistant engineer. In 1864 he came to the Pennsylvania Railroad Co. on special service on the Pittsburg and Philadelphia divisions.

On Jan. 1, 1865, Mr. Brown was made roadmaster of the Pan Handle R. R. at Coshocton, and a month later promoted to engineer of the Oil Creek R. R., under Frank Thomson, who was then general superintendent. In June of the same year he became principal assistant engineer of the Philadelphia & Erie division, and on Sept. 1, 1867, was made engineer of the same division. On March 1, 1869, he was transferred to Altoona to build the new yards and car shops, which are now the largest railroad shops in the world.

Mr. Brown's tireless energy always kept him to the front and whenever there was a vacancy he was found to be the man to fill it. So in January, 1870, he was promoted to the position of resident engineer of the Middle Division of the Pennsylvania R. R., with headquarters at Altoona. This position he held until March, 1871, when he became superintendent and chief engineer of the Sunbury & Lewistown R. R. In August of the following year he was made superintendent and engineer of the Bedford Division. On Aug. 1, 1874, he was promoted to the position of engineer of maintenance of way, with headquarters at Philadelphia, and on June 1, 1881, he became chief engineer of the company.

Since that time Mr. Brown has seen many changes in the physical condition of the railroad. While there was never any looking backward the progress was never as advanced as it has been since 1899; since President Cassatt has been at the head of the company. It is safe to say that no railroad chief engineer has ever had as much money at his disposal as the chief engineer of the Pennsylvania Railroad Co. With this powerful backing he was in a position to go ahead and undertake work that other railroad engineers would have hesitated to do.

Mr. Brown's work includes all that pertains to the construction of a railroad. When asked what he considered the most important operation he ever undertook, he hesitated and finally said: "All work is more or less important, but I guess the greatest piece of work I ever did was the construction of the Broad Street terminal and station in Philadelphia. I have also built other stations, but this was the first of its kind and is as good to-day as when first completed."

Mr. Brown is justly proud of his work in connection with this station. When the plans for it were made the railroad had its depot at 32nd and Market Sts., and to get an entrance into the heart of Philadelphia the right of way had to be secured. Private property was bought and the first elevated road into this city was built. From the west side of the Schuylkill River to Broad St., the line is elevated. The trainshed begins at about half way between 16th and 17th Sts. The lobby stretches over 15th St. and the general offices of the company include all the space in the eight-story building above the waiting room.

Since the trainshed was opened for business the trackage facilities have been increased so that now there are 16 tracks under the roof. The length of the shed is 598 ft. and its width 304 ft. The roof is carried on twenty trusses set in pairs 9 ft. apart, the distance from center of each pair varying from 60 to 67 ft. Mr. Brown takes great pride in this shed, especially the manner in which it was constructed. Prior to its erection there was one only a little over half as large. During the time the new one was in course of construction there was no delay in the movement of trains owing to the work that was going on in the station.

While Mr. Brown looks upon this operation as one of the most important he has directed, the officers of the company believe that there are many other operations that were of more importance to its affairs. It was through Mr. Brown's work that the system is now a four-track line between Jersey City and Harrisburg and there are very few stretches on the other divisions that have not four tracks. To refer to all the work that Mr. Brown has planned would take many pages of this paper. It is safe to say that there has not been a plan of prominence issued from the company's office since he has been chief engineer that he has not passed an opinion on. The work of eliminating grade crossings on the New York Division was designed by him, and there were a number of great engineering problems that he had to solve. For instance the road is now elevated through the northern section of Philadelphia as well as through Newark and New Brunswick, and within a short time there will not be a grade crossing on this division.

The Broad St. Station of the Pennsylvania R. R. at Philadelphia

The Johnstown flood was one of the many incidents which showed what kind of material Mr. Brown was made of. He was among the first to reach the scene of desolation and loss of life and it was not long before, under his direction, a system was organized which resulted in the opening of the line. Mr. Brown took personal charge of this work. He was in danger of losing his life several times. While making soundings in the Conemaugh River, which was swollen many times above its normal condition and was out of its channel for nearly all its course, he lost his balance and fell overboard. He could not swim, but managed to keep afloat and grasped a log which he held on until he was rescued. When taken out of the water he promptly resumed the work that he was interrupted in when he fell overboard.

There is no man in this country that has a wider reputation as a bridge builder than Mr. Brown. His promptness to take up such work has always been a source of congratulation by his superior officers. Some years ago while he was stopping at the Mountain House at Cresson, which the company owned at that time, he was talking to Mr. Welsh, a director of the company, when a doctor of divinity joined the party. The minister was a friend of Mr. Welsh, who introduced Mr. Brown to him, saying: "Doctor, I wish to present to you the greatest railroad bridge builder in the world." The minister gave Mr. Brown a look and then, delivering what he supposed would be a blow to his ability as a bridge builder, said: "Mr. Brown, could you construct a bridge from here to eternity." Without a moment's thought Mr. Brown's reply was: "Yes, if you will furnish the abutments."

Mr. Brown is a great believer in stone bridges and wherever it is possible he has built them to take the place of steel ones. Among the most important bridges he has constructed is the one across the Susquehanna River, west of Harrisburg. This is one of the longest bridges in the United States and the largest stone arched bridge in the world. He has also constructed many bridges on the main line and over the Delaware River at Philadelphia and Trenton.

Besides the engineering work of the Pennsylvania Railroad, Mr. Brown is one of the consulting engineers of the New York terminal railroad, where he has full charge of the tracks and terminal department. It is likely that he will continue to look after this work until it is completed, and there is a possibility he will continue in office with this company, as it has no rule by which an employee is required to retire when he becomes seventy years of age.

There is no officer who will be more missed than Mr. Brown after his retirement. He has been chief engineer of the Pennsyvania R. R. for so many years that it is felt he is a part of the system. He has grown up with the road and there is not a part of it that he has not tramped over many times. One of the most important pieces of work now under way is the building of a low grade freight line from Susquehanna River at Columbia to Glen Lock. This road will be of easy grade and will permit the company to haul much larger freight trains than it now runs over the Philadelphia Division. To build this road there was a great amount of filling in, besides a large amount of blasting and excavating. Near the Columbia & Port Deposit Road a small mountain had to be torn down. While this work was under way the traffic on the Columbia & Port Deposit Road was shut down. Mr. Brown has also prepared plans for the continuation of the low-grade line from Glen Lock to Philadelphia. This road will have only three curves and they will be of no moment. It is expected that this work will be begun this year. When it is completed the Pennsylvania Railroad Co. will have practically a new freight line from the Allegheny Mountains to Philadelphia. This line will run around the principal cities through which the main line now passes and will in a great measure do away with the congestion of the interior terminals.

To give even a list of the work that Mr. Brown has done would be like writing a book. However some of the most important operations that he has had charge of, according to a statement made by himself, are as follows: The improvements in and around New York, consisting of the company's terminals in Jersey City and Greenville, where the greatest classification yard in the country is being constructed; the rebuilding of the Jersey City station four times, in 1875, 1891, 1896 and 1898, and also the Jersey City Elevator; a new line to Bergen Hill, a new bridge across the Hackensack River, the elevated road through Newark, New Brunswick and Elizabeth, the Newark Bay road to Greenville, the New Brunswick bridge, a new iron bridge over the Raritan River, the new stone bridge over the Raritan River in 1901, the four tracks through Trenton and the new bridge across the Delaware River at that city, the Delaware River bridge and railroad in Philadelphia and the New Jersey, West Jersey & Seashore Railroad ferries, the grade crossing tunnels at the Zoological Gardens, the Germantown & Chestnut Hill R. R., a part of the Schuylkill Valley R. R., the piers and docks on the Delaware River front in Philadelphia, bridges across the Schuylkill River, the passenger station at 32nd and Market Sts., in Philadelphia, the West Philadelphia stock yards, and the elevated line through the West Philadelphia yards, eleven tunnels in West Philadelphia, the 41st and Girard Ave. bridges in Philadelphia, a practically new line from Philadelphia to Harrisburg.

The Rockville Bridge on the Pennsylvania Railroad Five Miles West of Harrisburg

Mr. Brown has also erected two new stations at Harrisburg. The Euola classification yards at Fairview were planned by him and he made the plans for the change of line west of Lewistown, as well as rebuilt the old Portage road. This is the road that the State used before the Pennsylvania Railroad Co. bought it. Even now the line of the old canal and the inclined plane can be traced. He built a new tunnel from Gallitzen through the Allegheny Mountains, the Scalp Level R. R., the Sang Hollow extension of the West Pennsylvania R. R., a new line from Latrobe to Beatys, a new line through to Irwin, a new station at East Liberty and two stations at Pittsburg. He elevated the grade of the line on the south side of Pittsburg, and elevated the road through Chester and Wilmington, built the new bridge at Havre de Grace, the new station at Baltimore, and has plans for another new station at this place. He planned the new terminals at Washington and the construction of the Brilliant Branch around Pittsburg.

Mr. Brown was asked if he had ever counted up all the money he had expended for the company. His reply was: "No. It has been a great deal. Much more than I would like to be worth." It is understood that he has given out contracts for over $500,000,000. His many friends will be glad to know that he has engaged passage to Japan and will sail early in March.

Sewage Experiment Station at Waterbury, Conn.

The sewage experiment station at Waterbury, Conn., contains three 4,000-gal. tanks and six 0.001-acre filters. One tank is being used for plain sedimentation for 24-hour periods, and the other two as 16-hour septic tanks. The sewage is delivered by a small centrifugal pump to a grit chamber and is then screened before it is admitted to the sedimentation tank. Three of the filters receive the sewage near their top surface and are being run as standard intermittent sand filters at rates of 100,000 to 200,000 gal. per acre daily. The other three filters are filled with 2-in. trap rock and are low enough to allow the settled and septic sewage to reach them under several feet head, enough to operate sprinkling devices. The station is under the direction of City Engineer R. A. Cairns, who stated at the meeting of the Connecticut Society of Civil Engineers recently that one or two filters may later be converted into contact beds. The experiments made so far indicate that the sewage does not contain enough industrial wastes to interfere with ordinary bacterial action.

A Large Power Plant with electric power distribution will be used in the new Wood worsted mills, at Lawrence. There will be a 5,000-h.-p., compound condensing engine, and an 1,800-h.-p., non-condensing engine furnishing its exhaust for heating, wool washing, dyeing and other purposes. Forty 78-in. by 20-ft. horizontal return tubular boilers with mechanical draft will furnish steam. About 5,000 h.-p. in induction motors will be furnished for running the machinery.

Power Development at St. Croix Falls for The Minneapolis General Electric Company.

By Adolph Edsten.

About a year ago Messrs. Stone & Webster acquired for the Minneapolis General Electric Co. riparian rights along the St. Croix River for a distance of twenty-one miles above the villages of St. Croix Falls and Taylors Falls, and immediately made plans looking to the development of the water power existing in the falls in that portion of the river. These falls, or succession of rapids, were one of the first localities in the upper Mississippi Valley to attract the attention of settlers and investors. In the early forties a band of pioneers located on the Wisconsin side, just opposite the falls and founded the village of St. Croix Falls. About the same time another band settled just below the falls and founded the village of Taylor's Falls and by these two names the falls have since been known. Confident that capital would eventually find them out and locate large industries on both sides of the river, the early settlers waited patiently for the development of the water power. They hailed with joy the announcement that Caleb Cushing had secured control of the power rights. He had been an officer in the Mexican War and, like many of his companions, sought land grants in the far Northwest. It was his intention to develop the power and make the locality one of the industrial centers of the new Northwest and a rival to the then youthful but lusty village at the Falls of St. Anthony on the Mississippi River, forty miles away. He sent a Mr. Perkins from the East and everything looked promising, but for some reason or other the plans came to naught. The water power rights were later on secured by Isaac Staples, a wealthy lumberman of Stillwater, twenty miles downstream. While many plans for utilizing the power were proposed, none of them was ever realized. A dam was built about eleven miles above the two villages. It is known as the Nevers dam and is built almost entirely of timber. No attempt was made to obtain any power, however, and the dam served little purpose other than being of some convenience to the lumbering operations.

About a year ago, however, the Staples estate disposed of its rights to Messrs. Stone & Webster, of Boston. There is a general demand in Minneapolis for electric power for small industries which is difficult to supply. Nearly all the power available at the Falls of St. Anthony has long since been developed. After studying the various undeveloped water powers within a short distance of Minneapolis, the engineers selected Taylor's Falls as the most available one for their purpose. They organized the St. Croix Falls Minnesota Improvement Co.

and the St. Croix Falls Wisconsin Improvement Co., and let contracts for the entire development work to the Columbia Improvement Co., which sent out Mr. G. O. Muhlfeld as manager of the construction. Mr. A. W. Hunking, hydraulic engineer, and Mr. Lee H. Parker, electrical engineer, represent Messrs. Stone & Webster.

The company controlling the power acquired the entire flowage rights on both banks of the river for a distance of 21 miles, including also the Nevers dam. This stretch of river will soon become a lake more than twenty miles long with an average width of a third of a mile. At the dam the reservoir will have a depth of more than 50 ft., and will deliver the water to the turbines under an effective head of 55 ft. at all seasons of the year. The estimated capacity of the new plant is 24,000 h.-p.

The preliminary work of the company included the erection of a two-story stone office building in St. Croix Falls for the use of the executive officers and the engineers, the rebuilding of an existing house as a home for the superintendent and engineers, and the erection of a couple of barracks for the laborers. After the work had been fairly under way it was planned to employ about 500 men, but labor was exceedingly scarce in the Northwest in the summer and fall of 1905, and the total number on the works rarely exceeded 400 men and averaged about 300. Of this number 200 were employed on the day shift and 100 on the night shift. The work has been prosecuted as rapidly as the labor conditions and the weather would permit. It is expected that electric power will be delivered to Minneapolis about June 1 and a strenuous effort is being made to get the dam across the river before the spring break-up. The accompanying photographs by Mr. Edmund A. Brush of Minneapolis show the general character of the site and the plan of construction.

Actual work was begun on April 28, 1905, immediately after the completion of a spur track from the Minneapolis, St. Paul & Sault Ste. Marie Ry. to St. Croix Falls, on the Wisconsin side of the rapids. By means of this spur all material used in construction is delivered within such distance of the works as to permit its handling by derricks and tram cars. A cableway has also been stretched across the river to facilitate the work. Since everything was fairly started, ten steam drills have been in constant use on the excavation of the trap rock. This work goes on night and day, blasts being touched off three times daily. Eight derricks have been in constant operation.

The dam is composed of rubble concrete. Broken stone for the concrete is obtained in the excavation for the canal and power house, the material being very hard. The same ledge also forms the foundation for the dam itself. Sand for the concrete is obtained from a bank about a fourth of a mile east of the works on a sidehill, from which a gravity railway delivers the sand to bins immediately over the concrete plant. The two mixers are of the Smith type, with a capacity of a cubic yard per batch. The crushers are capable of breaking about 200 cu. yd. of rock per ten hours.

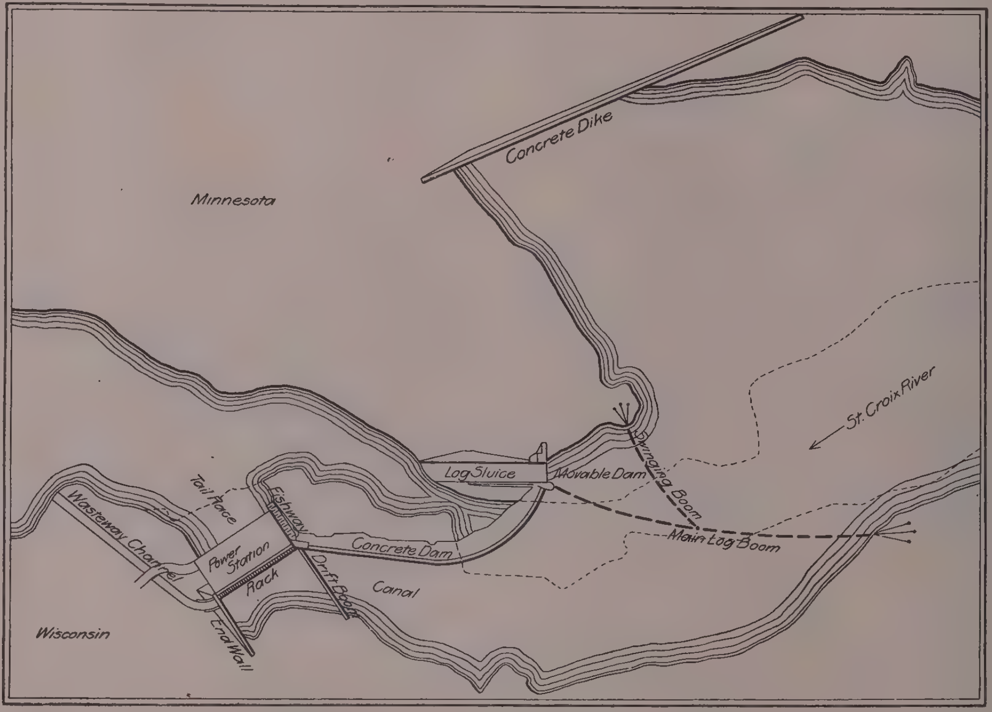
The concrete is mixed in proportions of one part of cement, three of sand and five of broken stone, except for the facing on the overflow sections of the dam, in which the proportions are one, two and four. To prosecute the concrete work during the cold weather, steam has been used in heating the rock and sand in their respective bins and hot water has been provided for the mixing. The trap rock used in the concrete proved exceedingly hard, having a specific gravity of 3.0. It has been extremely difficult to work in this material, as it has been very trying to the crushers and drills.

The concrete is delivered in steel skips and carried away on cars drawn by horses over a trestle work constructed along the dam and power house, from which it is taken by derricks and delivered wherever wanted.

The dam averages about 50 ft. in height and has a vertical upstream face and a downstream face of about sixty degrees slope. Starting from the Minnesota shore, the dam crosses the stream nearly at right angles, then bending southerly it runs almost parallel with the Wisconsin shore a distance of nearly 350 ft., the total length of the spillway being 650 ft. The dam has a thickness of about 50 ft. at the base, diminishing to about 10 ft. at the top.

At the westerly end is located a log sluice 40 ft. wide between cut stone piers and controlled by a steel bear-trap gate about 10 ft. high. The St. Croix River is still used by the lumbermen in floating logs and the sluice is introduced in the dam for their convenience although lumbering operations are now conducted only on a limited scale and will probably disappear entirely in a few years.

A forebay or canal between that portion of the dam parallel to the Wisconsin shore and the shore itself leads to the power house, which is located at the downstream end of the dam. Most of this canal is blasted out of the trap rock ledge, the cut varying from 0 to 28 ft.



General Plan of the St Croix River Power Development

The power house itself is a structure 86x203 ft. in area, the canal wall of which is really a continuation of the dam. The station is built of solid concrete and has been designed for eight units of 2,500 kw. each, together with two exciter units of 100 kw. each. For the present only four of these units will be completed, the other four being carried forward only so far as may be necessary to insure the entire closure of the forebay. This is accomplished by an end wall from the southerly end of the power house easterly to the trap rock ledge. The four units which are to be completed at first consist of steel flumes 14 ft. in diameter and about 42 ft. long, which are bedded in concrete in the canal wall of the power house. Within each of these steel flumes will be four 27-in. Victor turbines on one shaft, to the outer end of which will be coupled a 2,500-kw. generator. The turbines, which develop 4,200 h.-p., receive their water through a tube 14 ft. in diameter, joining the pen-stock on top and with a quarter turn extending to the canal face of the power house. Along the entire front of the power house there will extend a fine steel trash rack in front of the intake to the water-wheels.

Across the forebay or canal just above the power house will be maintained a boom for catching floating débris and a wasteway in the dam at this point will wash the débris into the river. In the end wall of the canal there will be another wasteway, 10x10 ft., for removing accummulations which may pass the first boom. Suitable booms will also be provided for storing logs and forcing them into the log sluice. In addition, a fishway or ladder is provided at the northerly end of the power house, by means of which fish may pass from the lower level of the river to the upper.

In the construction of the dam six openings were left, each about 10x12 ft., and these are calculated to take the flow of the river, when the current is entirely shut off by a cofferdam across the main channel. These openings will be closed ultimately by timber gates and will be filled with concrete from the downstream side.

The company owning the dam controls the flowage rights for 21 miles upstream and will be able to pond the flow of the river for several hours at a time, thereby enabling the contractors practically to cut off the entire flow of the stream while the openings are being filled.

Ever since the work began the flow of the stream has been unusually large and for some time prevented successful attempts to build a cofferdam. In November, however, a cofferdam was begun. It was composed of cribs, loaded with stone, double planked on the vertical upstream side with straw and gravel. About the time this was made reasonably tight another unexpected difficulty was encountered. Owing to the unusually mild winter the river did not freeze over completely and each day small sections of slush ice flowed downstream, landing a mile or two below the works and forming an ice barrier, which raised the water some 12 ft. above the normal stage at the dam works. This state of affairs called for a second cofferdam parallel with the first, but on the downstream side of the dam. Between these two temporary constructions the dam is being constructed.

The lower cofferdam is built of sawed lumber 2x6-in. scantling, random length, spiked flatwise on each other, forming two walls about 10 ft. apart and frequently tied with cross timbers. Between the two walls there is a boxed section to receive stone and gravel to sink the dam as the construction progresses. This will also have a vertical double planking and be filled with gravel. The space between the two dams will be pumped out by two large, centrifugal pumps.

Another cofferdam was needed to protect the tail race excavation, which will extend into the river nearly 175 ft. from the wheel pit outlets. The floor of this excavation is an inclined plane extending from the wheel pit at a grade of four feet in a hundred. This cofferdam was built of earth and presents no unusual features.

On the Minnesota side of the river a low swale caused by a dip in the bank exists and this had to be diked off to retain the water. For this purpose a concrete dike has been constructed. It has a maximum height of 30 ft. The total length is about 1,000 ft. The width of the dike is about 5 ft. at the top and 16 ft. at the base. The construction in this instance was the same as in the case of the main dam except that gravel was used instead of broken rock, a pit of excellent gravel being found nearby.

The generators will be of the Westinghouse alternating current type, furnishing current at 2,300 volts. It will be transformed for high potential transmission at 50,000 volts, at which voltage it will be brought to the Minneapolis substation, where the voltage will be cut down to a suitable voltage for commercial purposes. Twelve transformers will be installed at the power house and nine at the sub-station. The transmission line is over a private right of way purchased by the St. Croix Falls Minnesota Improvement Co. It is a fraction more than 40 miles in length from Taylor's Falls to the Minneapolis sub-station, and has a uniform width of 60 ft. Steel towers have been erected for the purpose of carrying the wires over lakes and depressions where it is impossible to place poles. The insulators, which are 14 in. in diameter and weigh 25 to 30 lb., have been tested to withstand three times the required voltage and are calculated to prevent any leakage of the current.

After the line is in operation it will be patrolled continuously and private telephone booths have been placed at regular distances for the convenience of line walkers in making reports. The company has also leased a line from one of the telephone companies as an emergency line in case of interruption on its own line.

General View of the Works for Power Development on the St. Croix River

View Showing Character of Work at the Site of the Power House

Rubble Concrete in Dam

Wheel Casings and Draft Tubes

THE CONSTRUCTION OF THE CHARLES RIVER DAM AND BASIN AT BOSTON.

By John N. Ferguson, Assistant Engineer, Charles River Basin Commission.

Work under the direction of the Charles River Basin Commission during the past season has included, principally, the completion of a temporary highway bridge and approaches, work preliminary to the construction of the dam and lock, including the removal of a portion of Craigie Bridge, completion of the construction of the Boston coffer-dam, dredging and pile-driving therein, construction on the Cambridge coffer-dam, and the completion of Section 2 of the Boston marginal conduit. The elevations given in this article refer to a base 100 ft. below Boston city base, which is approximately mean low water. For detailed description of the location and designs of the dam and lock one is referred to The Engineering Record of Nov. 26, 1904.

In accordance with chapter 465 of the Acts of the year 1903, authorizing the construction of the dam and lock in the Charles River, the Commission was required to remove Craigie Bridge, as the dam is to occupy, substantially, the site of the bridge. The Act also required the Boston & Maine R. R. Co. to remove its freight bridge and appurtenances southerly and westerly of a line located 400 ft. from the downstream face of the proposed dam at the Cambridge shore, and about 360 ft. from the face near the lock. Studies were made as to the best method of caring for the traffic over Craigie Bridge during the construction of the dam, and it was decided to use the railroad bridge for a part of a temporary highway bridge after the necessary legislation and consent from the railroad officials had been obtained.

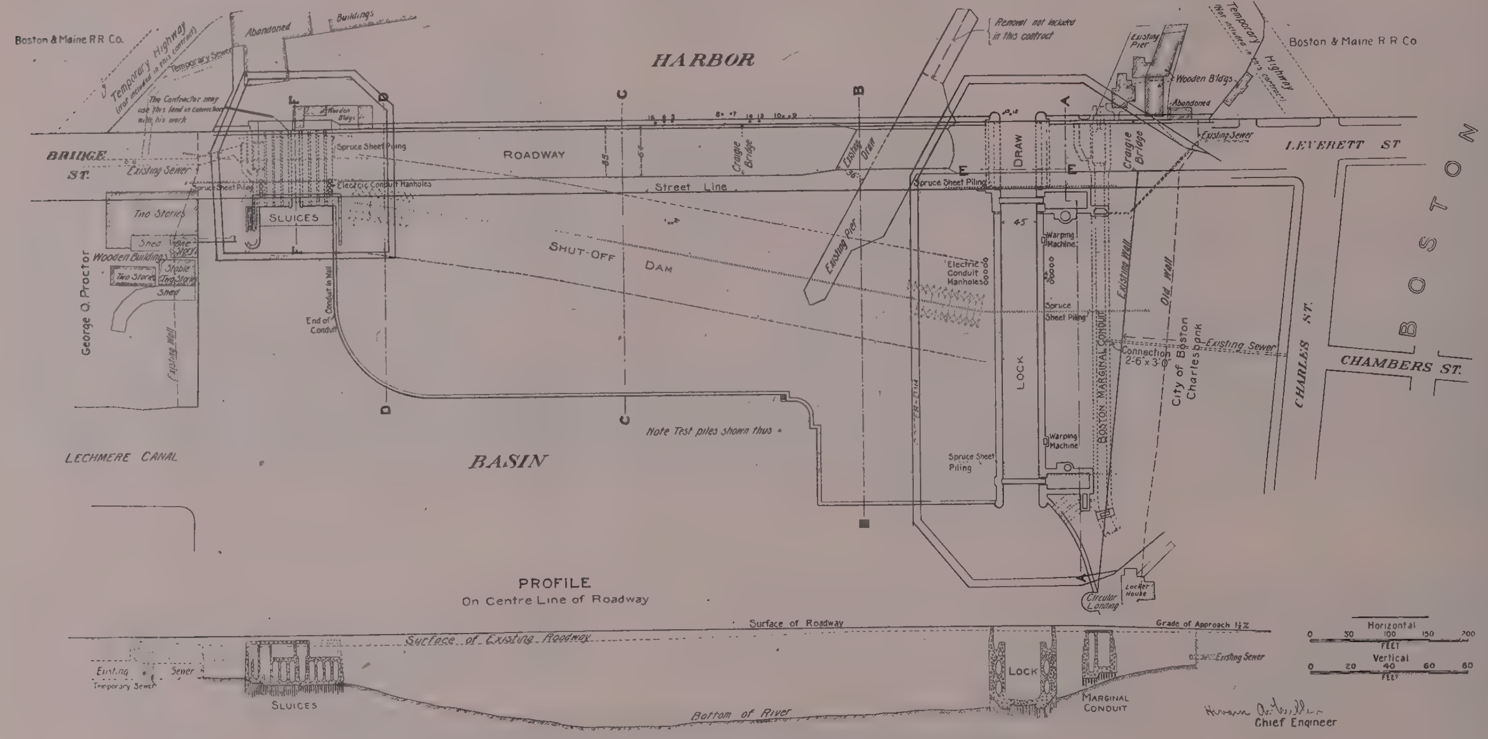
Temporary Highway Bridge.—The railroad bridge was utilized for the main portion of the temporary highway bridge, that west of the channel, and a new draw and new pile bridge east of the channel were built. The railroad bridge was reconstructed to adapt it to highway purposes and strengthened by driving additional piles, splicing old ones, adding new stringers and in other ways.

The contractor, Holbrook, Cabot & Rollins Corporation, of Boston, began work on the new portion of the bridge on March 1 and began pile-driving on March 2, 1905. The pile caps, braces and stringers, where adjacent, were rigidly attached to the bents of the Boston & Maine R. R. bridge. Stringers were long enough to span two bays, notched to fit the pile caps and laid to break joints. Roadway and sidewalk planking was planed on one side to an even thickness and the sidewalk planking jointed. The full width of the roadway, including one sidewalk, is 48 ft. The work also included the changing of the draw channel, building a guide pier and constructing fenders. The draw consists of four leaves operated in pairs and lifted by two 25-h.-p. motors. About 500 spruce, Norway pine and oak piles, having a maximum length of 69 ft., were driven in the guide piers, fenders and the bridge by means of floating and track pile-driving machines. On June 28 a trial street car was run over the bridge, and on July 2, 1905, the bridge was opened to travel and Craigie Bridge closed.

Coffer-dams.—On January 14, 1905, the contract for the main portion of the dam and lock was awarded to the Holbrook, Cabot & Rollins Corporation. The work includes the construction of a dam about 1,300 ft. long across the Charles River between the cities of Boston and Cambridge. Two coffer-dams are required at the shore ends of the dam. Within the coffer-dam on the Boston side, a navigation lock, section 1 of the Boston marginal conduit, foundations for a drawbridge, gate chambers and other structures will be built. Within the coffer-dam on the Cambridge side sluices for discharging the flow of the river, a portion of a marginal conduit and other structures will be built. The coffer-dam on the Boston side, generally rectangular in shape, being 625 ft. long in a northerly and southerly direction, parallel to the river, between the inner rows of sheeting, and 255 ft. wide at its middle, covers an area of 3.8 acres inside the outer row of sheeting. It has three constructed sides, the Charlesbank Park forming the fourth, measuring 1,190 ft. from wall to wall. Suitable cut-offs in addition extend back of the wall at each end through the old sea-walls and apparently through stone filling.

Subject to the approval of the chief engineer, the contractor was allowed to construct coffer-dams of other designs, or in other locations, than those shown on the contract plans, but their sufficiency rests upon the contractor. He was allowed to substitute in place of a dam 30 ft. between inner sheeting one which is 8 ft., and to change its location slightly relative to the fill. The coffer-dam was designed by Mr. Frederick H. Fay, consulting engineer, of Boston, Mass.

The construction of the coffer-dam began on March 9. Structurally it consists of two rows of guide piles 11 ft. apart with piles 10 ft. on centers having alternate spur piles, supporting two rows of 6-in. splined and grooved sheet-piling, the whole thoroughly tied and braced. The quantities per linear foot called for by the design are as follows: 6-in. yellow pine grooved sheeting, 38 ft. long, 456 ft. B.M.; wales, struts and fillers, 107 ft. B.M.; spruce, including splines, 31 ft. B.M.; 1¼-in. bolts and washers, 24¼ lb.; 1-in. and ¾-in. bolts and washers, 12 lb.



Plan and Profile of Charles River Dam and Basin, Boston, Mass.

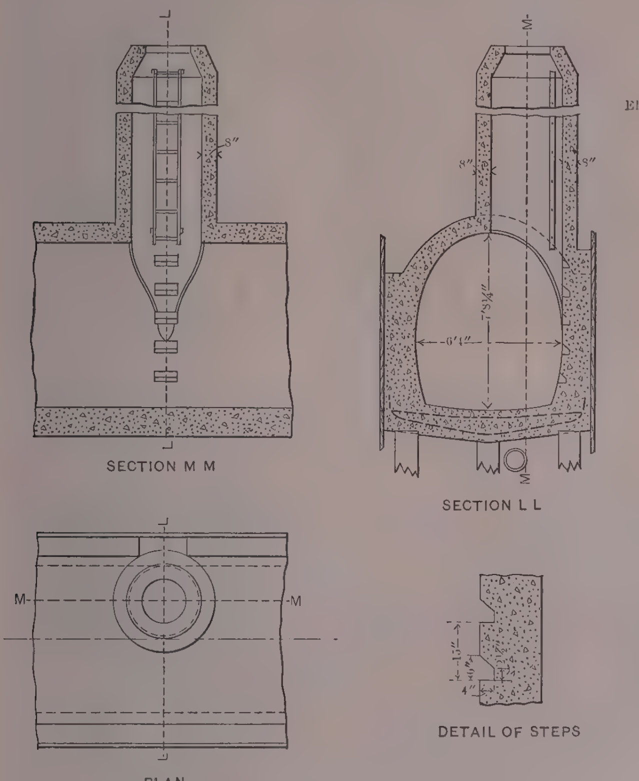
On July 5 the contractor commenced removing a portion of Craigie Bridge, the draw being dismantled first, as it came in the line of the coffer-dam construction.

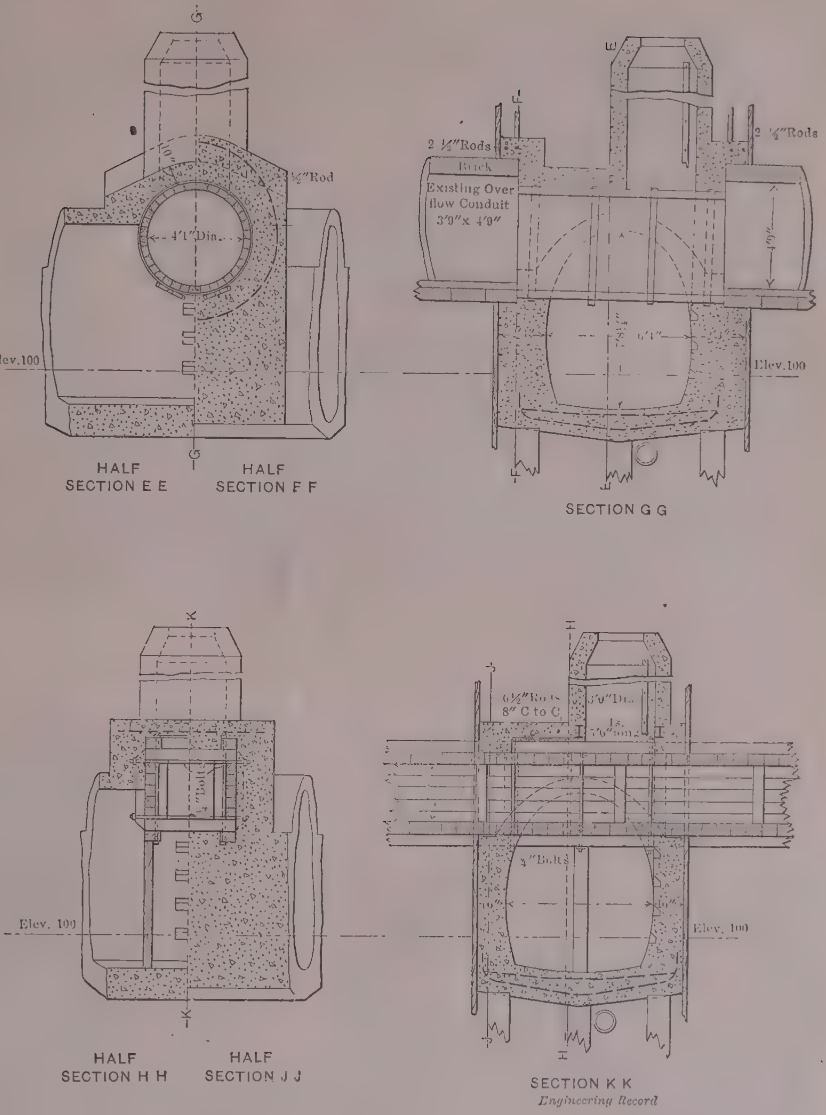
A total of 437 spruce piles of an average length of 45 ft. were driven, and about 740 M. ft. B.M. spruce and yellow pine were used in the coffer-dam and shore connections. The specifications called for spruce, oak or Norway pine piles not less than 11 in. in diameter at the butt and not less than 6 in. in diameter at the tip, dimensions being exclusive of the bark. The yellow pine timber was square-edged inspection. The wales were bolted to the guide piles by one ¾-in. bolt at each pile. The sheet piles with spruce splines were driven vertically and close together with a floating machine fitted with outrigged movable gins to hard bottom, or given at least a 15-ft. penetration. Considerable care was taken to make the lines of sheet-piling as tight as possible, and a diver was engaged to make examinations and to report any pile broken or improperly driven. A lighter, fitted with an air compressor, was used in boring the piles and timbers. All angles were reinforced with iron plates and rods. At the shore ends of the dam, the sheet-piles mainly in one row, the inner row being discontinued, were driven with a land machine.

The filling between the rows of sheet-piling is composed of clay, silt and sand, the embankment on the inside of clay and sand, and the embankment on the outside of clay and gravel. The only trouble from washing the outside embankment, due to velocity of tide, occurred at the northwest corner near the draw channel. This has been satisfactorily protected by building plank jetties out from the slope. Filling began on May 22. A total of 117,500 cu. yd. of material was placed in the coffer-dam, some of which came from the excavations within the coffer-dam, but the larger part came from Boston Harbor where dredging was being done and from gravel banks in the river above Cambridge bridge. Some excavation from the Washington St. tunnel and from the Boston marginal conduit was filled at the shore ends. An opening was left at the southwest corner for the exit of the dredge, rehandler and floating pile-driver.

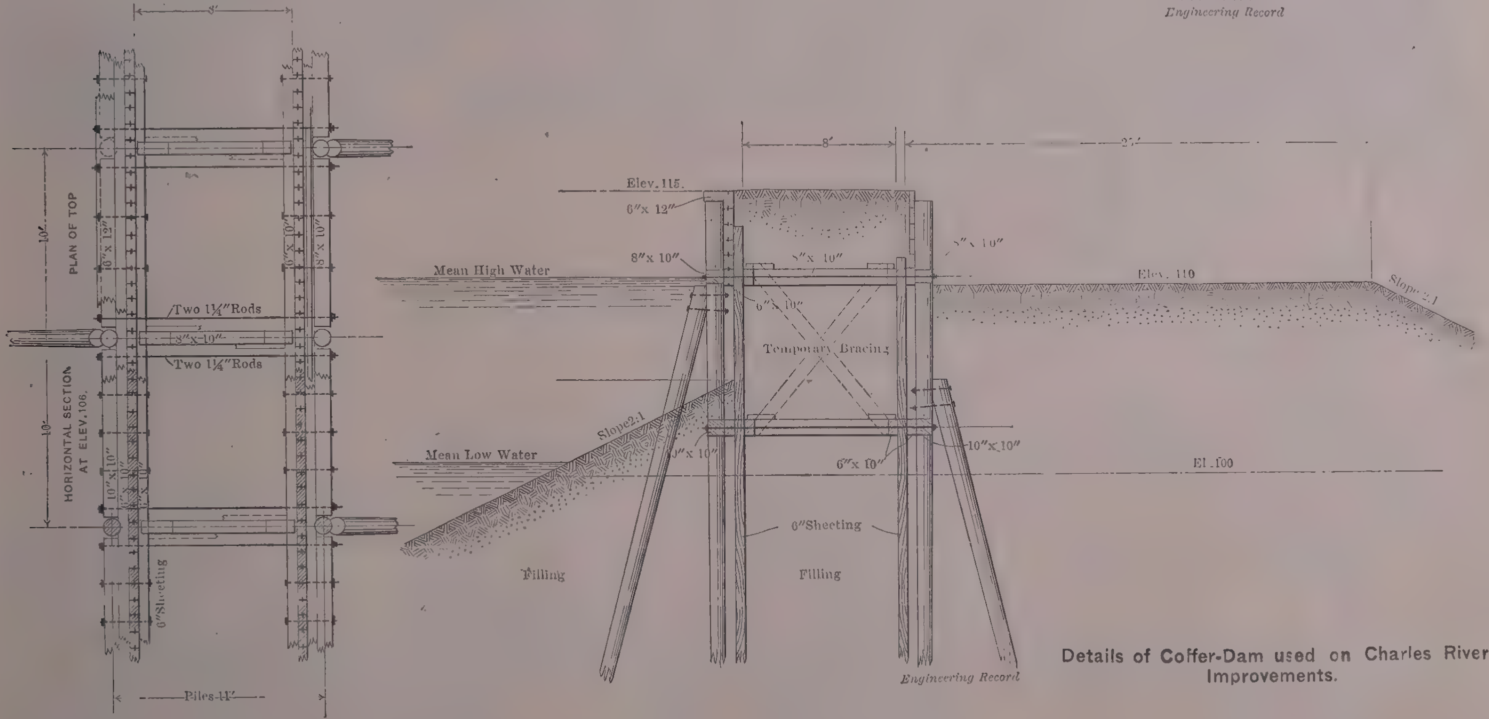
Near the middle of the south end of the coffer-dam, a sluice, with bottom at El. 100, was cut through after the sheet-piles had been driven. This sluice has two gates, one 2½x5 ft., and the other 5 ft. square, having a total net area of 36 sq. ft. These gates were left open until such time as sufficient material had been filled against the dam at the point of closure. They are operated by means of ratchet gearing, and also will serve to flood the dam in case of necessity.

The depth of water within the coffer-dam at low tide varied from nothing at the Charlesbank wall to 20 ft. at the northwest corner.



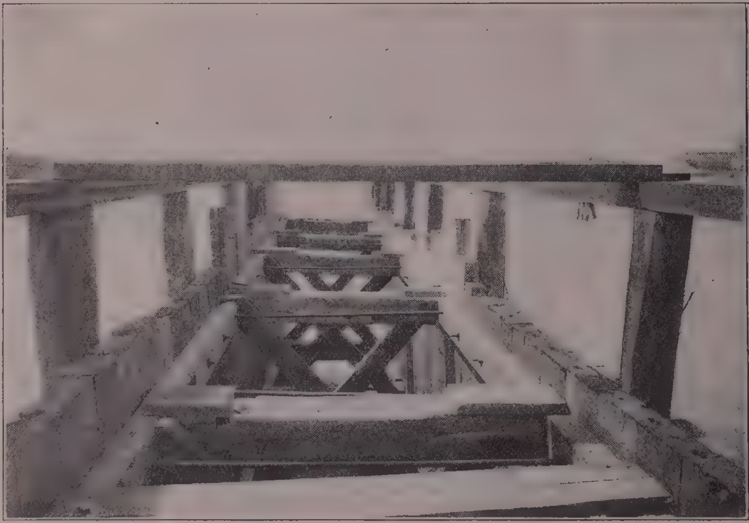


Standard Manholes and Crossings of Existing Overflows.



Details of Coffer-Dam used on Charles River Improvements.

On October 1 the sluice gates were closed and pumping out of the coffer-dam began, frequent stops being made to allow the fill to settle and the water to drain from the inside slopes. Movement of the slopes or appreciable increase in leakage was not noticeable. At first a 15-in. Lawrence centrifugal pump was used, direct-connected to a Westinghouse, Jr., engine, erected on a float, having flexible pipe connections from a steam plant placed on pile foundations on the westerly side of the coffer-dam. After the water had been lowered sufficiently, the pump and engine were placed on the inside fill and connected with a pump-well. Two 6-in. centrifugal pumps, one steam and one electrically driven, have been added, one of which takes care of the leakage, operating intermittently, the other being kept in reserve. The pump-well was excavated to about El. 64.5, from which was laid an 18-in. underdrain towards the center of the lock. It happens that the location of the coffer-dam encloses the outlet of an overflow from the west side intercepting sewer of the City of Boston, the discharge from which occurring during storms has to be taken care of. A sluiceway to take the discharge from the pumps was built out and over the westerly side of the coffer-dam. The price bid for the coffer-dam, which includes the cost of maintaining and the removal of certain portions, was $70,000.



Bracing in the Boston Coffer Dam.

Piles under Old Sea Wall, Marginal Conduit.

In the construction of the coffer-dam, no serious difficulties were encountered. The final closure was made Sept. 29, and the dam continued to successful completion. The care with which it has been constructed is well shown by the leakage which amounted, on an average, during 24 hours, to 400 gal. per minute, when the water inside has been pumped down to about El. 90. The rise of tide which is about 10 ft. does not seem to increase the leakage.

Dredging and Foundations for Lock.—Dredging for the lock began on April 27. The bottom of the masonry for the lock will be at El. 72.5, 27½ ft. below mean low water, which, with the excavation for the lock gate recesses, required the dredging of about 32,900 cu. yd. of material, some of which was placed in the fill for the main dam, the larger part, as previously stated, being placed in the fill for the coffer-dam. At the northerly end of the lock it was found necessary to dredge some material below the bottom of the masonry and to refill with gravel.

The contract required that the piles under the lock should not be driven until after the coffer-dam was pumped out, but, at the northerly end of the lock, where it was found necessary to dredge below the bottom of the masonry, the contractor was allowed to drive about 500 piles. These were driven in from 20 to 30 ft. of water by means of extension gins and a follower. The bottom of the pile was held in place by means of dogs attached to the lower ends of the extension gins. After the dogs were forced into the pile on opposite sides, the pile was lowered into position, and the dogs were forced further in as the pile was driven, their hold being lost after the pile had started into the bottom. The top of the pile was held in position by means of a cup-shaped casting at the lower end of the follower. A total of 514 piles were driven in this manner between Aug. 8 and 15. Pile-driving with land machines for the foundation of the lock masonry began on Oct. 31 at the northerly end. The piles were first driven in bents 14 ft. apart in the center of the excavation, the driver having an overhang of from 16 to 18 ft. These piles were left high and capped to serve as a trestle for a traveling derrick, and a grillage was built from it from which the other foundation piles were driven. Piles under the center of the lock are 4 ft. and 5 ft. on centers, those under the side walls are 2½ ft. on centers. Driving has been done at the rate of about 1,000 piles per month.

The plant for furnishing the material and mechanically mixing the concrete is in process of erection. It is intended that sand and gravel will be dumped from scows off the northerly end of the coffer-dam. Here a gridiron has been built on piles on which a rehandler will be placed to deliver the sand and gravel at the top of the hopper. The hopper is supported over the coffer-dam by heavy framed timbers at such an elevation as to separate the sand from the gravel into two large storage bins. Gaging boxes at the bottom will measure the sand and gravel, which, mixed with the cement, to be stored near by, will be carried by a belt conveyor to a cubical concrete mixer. The mixer is placed near the northerly end of the lock whence the concrete will be transported on cars to places needed.

The Cambridge coffer-dam is now being constructed. It will have an area of 1.2 acres and is being built on the same design as the Boston coffer-dam, except that it will have coffer-dam construction on all sides instead of utilizing the shore for one side. This method of construction was adopted partly to obviate the necessity of providing and maintaining a new outlet for the Bridge St. sewer. The piles for the foundation of the sluices are being driven by a floating machine similar to the one described as used in the Boston coffer-dam. The price bid for the construction, maintenance and removal of portions of this dam was $27,000.

Boston Marginal Conduit.—As the basin is intended to be used for pleasure purposes, it is essential that the condition of its waters should not only be harmless, but there should be no suggestion of sewage, that the enjoyment of the water park may be increased. Before the completion of the dam the commission is required to construct two marginal conduits, one on the Boston side and one on the Cambridge side of the lower portion of the basin, to conduct below the dam the overflow from sewers, the surface drainage and other refuse matter which would otherwise pass into the basin.

The conduit on the Boston side is known as the Boston marginal conduit. The construction of Section 1 is included in the contract work for the dam and lock, as previously mentioned. Section 2 of this conduit, comprising 1,804 lin. ft., is now nearly completed. It starts at the southeasterly corner of the Boston coffer-dam, in the Charlesbank Park, and extends southerly through the Charlesbank and approximately parallel to the Charles River, with a maximum distance from the river of about 180 ft., to the southerly wall of the approach to the new Cambridge bridge. In addition, it comprises an overflow chamber and conduit near its upper end about 175 ft. in length.

Previous to letting the contract, 13 wash drill borings, having an aggregate depth of 530.4 ft., were made and samples obtained to ascertain the probable character of the material to be encountered in excavating and pile driving; also, advantage was taken of borings made near by in Charles St. by the City of Boston prior to the construction of the west side intercepting sewer. On June 13, 1905, the contract for this section was let to James Driscoll & Son, of Brookline, Mass. Work began on June 21, and has continued since.

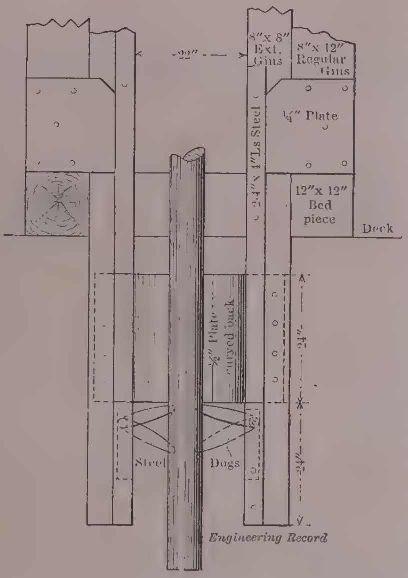
As the Charlesbank park was constructed by filling a water front, skirted by old sea-walls, bulkheads and docks, the excavation for the conduit was made through various kinds of material, including cinders, gravel, loam and so forth, as well as through the old sea-walls above mentioned. The line of the conduit was through practically level ground and required a trench about 20 ft. deep by about 10 ft. wide. A Carson-Lidgerwood cable machine, 300 ft. between towers, was used almost wholly for the excavation and refill. Portable stiff-legged derricks were used at the ends of the section where not advantageous to utilize the cableway, and a derrick having 72-ft. mast and 65-ft. boom with bull-wheel was used at the overflow chamber and conduit. The trench was braced and sheeted throughout with two sets of spruce sheeting, the upper set of 2-in. rough planks from 12 to 15 ft. long and the

Pumping and Pile-Driving Plant at the Boston Coffer-Dam.

lower set of 2-in. rough and 3-in. splined and grooved planks about 8 ft. long. The splined and grooved planking was used at the southerly end near Cambridge bridge to assist in preventing the inflow of tide water. The lower sheeting was required to be left in place and the masonry built against it. The braces and rangers used were 6-in. x 8-in. The trench was excavated to the form of the bottom of the masonry where in good material; where the bottom was peaty or silty it was removed to a depth of from 4 in. to 4 ft., and refilled with gravel.

Piles were not necessary for a distance of 422 ft. at the northerly end, as the bottom of the excavation was in hard sand or gravel and in one place for a distance of about 60 ft. through slate rock. The remainder of the conduit for a length of 1,382 ft. is built on piles. Spruce piles were used of a size not less than 10 in. in diameter at the butt and not less than 6 in. at the small end, dimensions being exclusive of the bark. They are spaced 2 ft. on centers under the side walls and 4 ft. on centers under the middle of the invert. The pile-driving was done largely at night, otherwise it would have interfered with the use of the cableway. The pile-driver had low regular gins so that it would not interfere with the cable, also extension gins to assist in driving the piles to grade in the 20-ft. trench. The hammer used was 9 ft. long, weighing about 2,100 lb., and the penetration required was equivalent to four blows in the last foot with a 10-ft. fall. For a distance of about 100 ft. the line of the conduit followed an old sea-wall built on piles with tops at about El. 100. Advantage was taken of these old piles, 243 being used after their tops had been cut off at the proper elevations. A total of 1,813 piles, having an aggregate length of 50,532.3 ft., were driven through silty sand and gravel to a hard bottom of stiff clay or to hard sand and gravel. The maximum length of pile used was 38 ft., the minimum length 17 ft.

Due to the proximity of the layout of this conduit to the river, the ground water, which varies according to the tide from about El. 103 to El. 108, caused a great deal of trouble to the contractor. Besides, the river water followed along the old sea-walls where uncovered and caused additional trouble. To care for the water a 10-in. underdrain of vitrified clay pipes was laid with gravel filling connecting with pump wells, constructed as the work progressed, about 500 ft. apart. The underdrain was laid with its top about 5 in. below the bottom of the masonry. A pulsometer and 4-in. and 6-in. centrifugal pumps were used, either separately or together, depending on the amount of water to be cared for.



Dogs on Extension Gin used in Driving Piles under Water.

The conduit has a cross-section 7 ft. 8¼ in. in extreme height and 6 ft. 4 in. in extreme width, with minimum thickness of bottom 15 in. of side walls 16 in. and of arch 8 in. The invert is built level at El. 98.5. The area of the conduit inside is 41.34 sq. ft., and the area of the masonry in section is 34.29 sq. ft.

The conduit was built of Portland cement concrete masonry mixed in the proportion by measure of 1 part cement, 2½ parts of sand and 4½ parts of broken stone or gravel. At the upper end of the line near the river the work had to be done at and about low tide, as it was next to impossible to keep the water out at high tide. Here the concrete was mixed in the proportion of 1, 2 and 4 parts of cement, sand and gravel, respectively. Whitehall, Alpha and Lehigh brands of cement were used. Screened gravel and screened broken stone, when the gravel was not available, were used; very little of it was more than 2 in. in greatest dimension.

Concrete was mixed by hand and also with a Smith concrete mixer. The mixer was placed near and operated by steam from the boiler on the cableway. The cableway served to convey the concrete from the mixer to platforms, from which it was shoveled into place. Towards the end of the work it was found that to get the progress desired it was not practicable to utilize the cableway for transporting the concrete as well as the excavation, so the use of the mechanical mixer was discontinued. The method of construction adopted was as follows: The invert was built in short sections, and after it had set sufficiently the forms for the side walls were placed and side walls built against the lower sheeting to a height of 4.7 ft. above the invert. After the side walls had set for 36 to 72 hours the forms were removed and the arch centers placed. The masonry of the arch was held in place on the outside of lagging carried up with the masonry. A mortar joint of 1 part of cement to 2 parts of sand was required between the side walls and arch, 1 bag of cement being used for 16 ft. of side walls. Additional concrete masonry between the prescribed lines and the sheeting was paid for at half the price for masonry inside the prescribed lines.

In the early part of the work lubricant was not applied to the forms, and their adhesion to the concrete caused some difficulty. Later the centers were brushed with soft soap each time previous

Pile Driver With Outrigged Gins.

to placing the concrete, and they were removed more readily. On the curves, which were either of 100-ft. or 800-ft. radius, straight forms 8 ft. long were used with 4-in. iron strips lapping the ends.

As will be noticed on the section, the bottom of the main conduit is reinforced with ½-in. and ¾-in. bent steel rods, placed over one another, 12 in. on centers. The ends of the ½-in. rods also increased the strength of bond between the side walls and arch. At the northerly end where the bottom was in hard material the rods were spaced 15 in. on centers. Ransome twisted steel rods were used in this construction.

The bottom of the lower set of sheeting was driven below the bottom of the masonry in order to prevent a direct flow of ground water from the sides of the conduit along the bottom of the masonry to the underdrain. Great care was taken to fill all voids directly behind the sheeting, particularly where there were old sea walls or rock fill. This was done principally by grouting, and in certain cases by allowing the concrete, at the time the side walls were built to fill in solid between the stones of the walls. At each end of the section brick bulkheads 12 in. thick were built in the conduit to keep out the ground water and filling.

The interior of the masonry, after removing the forms, was fairly smooth. After pointing was done it was given a wash of neat Portland cement applied with a soft bristle brush lengthwise of the conduit. The invert was plastered with mortar composed of 1 part of cement and 1 part of sand equal in thickness and finish to a plasterer's finished coat.

The finest of the excavated material was used for refilling next to the masonry and in the spandrel above the side walls where it was deposited in layers and well rammed. No large stones were allowed within 1 ft. of the top of the masonry. The material from the buckets was not allowed to be dumped directly on the masonry.

This section crosses two overflow conduits from the west side intercepting sewer, the use of which could not be interferred with during construction. The first overflow, a rectangular wooden conduit from 3 ft. wide by 2½ ft. high, was kept intact. It passes through the arch of the conduit and the masonry was carried over it and around its ends. It was first made tight by calking the joints with jute and plastering the interior with cement. The portion of the second overflow built of 8-in. brick on a wooden platform, being about 3 ft. 9 in. wide by 4 ft. 9 in. high, was cut out where it crossed the trench, and a wooden barrel, 9 ft. long and 4 ft. inside diameter, made up of staves 4 in. thick, was set up in place in line with the overflow. The barrel was built into the arch masonry, and additional masonry was placed over the barrel and around its ends. When the Boston marginal conduit shall be placed in commission, connections will be made with these overflows at their crossings.

There are four manholes on the main line built of 8-in. walls having an internal diameter of 3 ft. except at the top, where in a height of 1 ft. it decreases to 2 ft. diameter. The manholes are fitted with iron ladders having rounds about 15 in. apart.

As previously stated, the overflow chamber and conduit are located near the upper end of the section, the overflow conduit 6 ft. 5 in. high by 5 ft. 3 in. wide extending about at right angles to the main conduit. This overflow is provided in order to take the surplus flow of extremely dilute sewage during severe storms occurring at high tide. The connections at the overflow chamber are built to serve as a trap so that sediment or floating matter will not escape. The diluted overflow will be discharged through four openings in the side walls of the main conduit, then rise and flow over two cast-iron troughs with tops at El. 108.5, which is ½ ft. above the proposed water level of the basin, thence through the overflow conduit and pipes into the basin. In the construction of the overflow conduit practically the same methods were followed as in the construction of the main conduit. The concrete masonry in the roof and bottom of the chamber are reinforced with ½ and ¾-in. Ransome twisted steel rods. The bottom of the overflow conduit is reinforced with two ½-in. rods placed over one another 12 in. center to center. The placing of one length of 60-in. pipe at the end of the overflow conduit was included in this contract, the end of which was bulkheaded by two layers of 2-in. spruce planks laid at right angles to one another and plastered with cement. Later, connecting with this pipe, additional pipes will be laid through the Charlesbank wall and into the basin.

Stop planks are to be provided for the chamber and two tide gates, built by the Coffin Valve Co., after designs patented by Mr. C. H. Dodd and Mr. Edwin McLaughlin, of Boston, have been hung just outside the ends of the troughs.

The items, estimated quantities and prices bid are as follows:

Items.	Quantities.	Prices bid.
Earth excavation and refill (main conduit)	1,800 lin. ft.	$8.50
Earth excavation and refill (overflow chamber and conduit)......	175 lin. ft.	7.00
Rock excavation	200 cu. yds.	5.00
Piles	62,000 lin. ft.	.14
Underdrain	2,000 lin. ft.	.75
Concrete masonry (except backing).	2,600 cu. yds.	7.50
Concrete masonry for backing....	100 cu. yds.	3.75
Iron and other metal work*.......	45 tons.	8.00
Sheeting left in place............	70 M. ft. B.M.	18.00
Earth excavation in trench below masonry and underdrain........	200 cu. yds.	1.50
Gravel filling in excavat'n in trench below masonry and underdrain..	200 cu. yds.	1.50
Crossing of Fruit St. and Cambridge St. overflows		800.00

* All metal work was furnished by the Commission. The price given was for hauling, caring for and placing the same.

The Charles River Basin Commission consists of Dr. Henry S. Pritchett, chairman; Mr. Henry D. Yerxa and Mr. Joshua B. Holden. Mr. Hiram A. Miller, M. Am. Soc. C. E., is chief engineer to the commission and Mr. Frederic P. Stearns, Pres. Am. Soc. C. E., is consulting engineer. Mr. Frank E. Winsor, M. Am. Soc. C. E., principal assistant engineer, has charge of the designs, and Mr. John L. Howard, M. Am. Soc. C. E., division engineer, has charge of the construction work.

The Construction of the Rochester, Syracuse & Eastern Railway.

The 36-mile line of the double track Rochester, Syracuse & Eastern electric railway in central New York, is now being built through a chiefly rural and suburban district. It encounters a somewhat irregular topography which involves a considerable amount of cut and fill which has been carefully balanced and requires the construction of many culverts and some short bridges, viaducts and some longer spans. A road bed and structures have been carefully designed for solidity and durability under heavy traffic and are intended to be of first-class permanent construction comparable with that for steam roads. All cuts are made 32 ft. wide at the bottom with 1:1 slopes, and all fills are made 28 ft. wide on top with 1:1½ slopes.

Delivering Concrete from Mixer Driven by Gasoline Engine Directly Into Place.

In all cities and towns the tracks, 10 ft. apart on centers, are laid on standard 6x10-in. ties 8 ft. long and 2 ft. apart on centers which are bedded 1 in. deep in 6 in. of broken stone ballast about 19 ft. in width. Above the ballast there is a 6-in. layer of concrete which covers the bottom flanges of the 90-lb. American Society Civil Engineers standard T-rails and receives a sand cushion on which the brick pavement is laid in and between the tracks. Special bricks with beveled edges are laid next to the inner sides of the rails to provide suitable flange-ways. After the bricks are laid and tamped the interstices between them are filed with 1:1 Portland cement grout, thus providing a very hard, smooth pavement. Outside the outer track rails on each side of the roadway there is, in villages where the streets are not yet paved, a strip of macadam 2 ft. wide which the railroad company is under obligation to replace with paving whenever the remainder of the streets shall be paved.

In rural districts the distances between centers of tracks is increased to 12 ft., the brick paving is omitted, and the weight of the rails is reduced to 70 lb. All rails are 60 ft. long and are laid with continuous rail joint splices having four bolts each. The road is built with a maximum grade of 3 per cent in some short sections but the average grade does not exceed 1 per cent. The maximum curves are of four degrees except where it is necessary to turn sharp corners in city streets.

All of the excavation is classed as earth, but most of it really consists of hardpan covered with about 4 or 5 ft. of soft earth or loam. In the short cuts it is excavated chiefly with the Western Wheel Scraper Co Company slip scrapers and with their Nos. 2 and 3 wheel scrapers. In some cases a narrow cut was first dug deep enough for a team to pass through it. The deepest part was covered by a bridge on which the scrapers deposited their loads. A hole was provided in the bridge floor to allow the dirt to fall through into wagons in the cut below by which it was removed. The loam and upper soil was first loosened by six-horse rooters and four-horse ploughs, made by the Western Wheel Scraper Company. One of each of these machines has sufficed to prepare the ground for an average of fifteen 2-horse teams scraping and hauling.

In several cuts the hardpan was so refractory that it was necessary to make in it with hand drills 2-in. holes 8 ft. deep and about 10 ft. apart longitudinally and transversely. Each hole was charged with six sticks of 40 per cent. dynamite which was fired and shattered the ground sufficiently to enable it to be excavated. In one cut the hardpan was hauled an average distance of 500 ft. at the rate of 20 yds. in each 10-hr. day by each of the 20 teams employed there.

The largest cut was about 28 ft. deep and 800 ft. long; the longest one was comparatively shallow, but involved a haul of 2,600 ft. for the correspondingly long and shallow fill. In one cut 25 ft. deep there was 5,400 cu. yds. of excavation, in another one of the same depth 30,000 yds. and in a number of cuts there was from 10,000 to 12,000 yd. of excavation, the total amount of excavation averaging 20,000 yd. per mile for the 14-mile section of the road here described. The heavy cuts were made with one Marion G. steam shovel served with 18 narrow gauge 4-yd. side dump cars and two Porter locomotives and by two No. 20 and one No. 60 Marion steam shovels served by 6-yd. wooden body, steel truck, standard gauge, side dump cars drawn by one Davenport locomotive, and two American Locomotive Co.'s 19-ton locomotives.

Work Completed Between January 3 and 27, 1906.

A section of the road about 1,200 ft. long is built on an embankment 6 ft. high above the surface of a swamp 6 ft. deep to hard bottom. Here the soil was so soft that a man would sink in it up to his neck and in many places was covered with water a foot or more in depth. The road was economically and rapidly made across this place in the following manner. The swamp was thickly covered with brush, enough of which was cut to form a single tier about 15 ft. wide on the center line of one track. This was spread on the surface of the swamp and on it were laid two lines of green timber stringers cut in the vicinity. These supported the cross ties and enabled the track to be laid for some distance in advance of the fill.

A spoil car was pushed out on the track and dumped so as to make as high as possible a fill on one side of this track in line for the other track. When this embankment could be no longer built from the level of the first track it was roughly leveled and the rails were transferred to it. The spoil was then delivered on this track and dumped over the brush and stringers of the preliminary track, eventually sinking the latter to the bottom of the swamp and building up an embankment above the surface of the water. The track was then laid on this bank and the remainder of the fill was accomplished in the usual manner eventually forming a solid embankment which compressed the soft material of the swamp sufficiently to make a stable road bed. It is remarkable that this method of construction did not appear to occasion the loss of any material outside the regular slope of the embankment or to cause any upheaval of the soft material alongside, a result doubtless due to the hard bottom which underlaid the mud and water. The mud was apparently not even displaced to any great extent by the fill but on the contrary was compressed in its original position, since the amount of material required for the fill did not exceed the quantities estimated for the theoretical cross section more than about 25 per cent.

The broken stone ballast was delivered by 26 10-yd. center dump cars built by the Western Wheel Scraper Co. There were also used for transporting the rail and ties, 80 ordinary 40-ton flat cars and service for this work was maintained by a 30-ton four-wheel locomotive, built by the American Locomotive Co., by two 30-ton four-wheel switching locomotives and by three other 40-ton rented locomotives.

As soon as the grading was completed the track was laid on the dirt by a special train with one locomotive which pushed a flat car loaded with bolts, splices and 500 ties preceded by two flat cars loaded with rails. Two rails were thrown off and were dragged 60 ft. ahead by a team, half the required number of ties were also unloaded, put in position and the rails approximately aligned, spiked to them and connected with the end of the finished track by half bolted splices. The train then advanced to the end of these rails and the same operation was repeated and so on, laying in this way as much as 4,000 ft. of track in one day with a gang of 50 men. This train was followed by a gang of 25 men who put in the remaining ties and completed the spiking and splicing. The materials for the second track were, of course, delivered from the first track and it was laid at the rate of about 5,000 ft. per day by a gang of 50 men.

The ballast train followed the rail train and dumped on the center line of the track enough broken stone for the first lift. Ties were piled up three high across the track in front of the wheels of the rear truck in the train and as the train moved forward they acted as a rude scraper and ploughed the ballast in both directions, distributing it on opposite sides of the track and leaving its surface approximately level. Afterwards a second train delivered the remainder of the ballast and the track was accurately graded, and aligned. These operations required about 50 men for each ballast gang and 8 or 9 men to line up.

As much of the line was remote from the railroad difficulty was experienced in some cases in transferring to it the steam shovels and heavy cars which required a standard gauge track on which to be moved. At Palmyra half of the plant was taken across the Erie Canal at a point where there was no existing bridge to carry it. The temporary track laid for it intersected the track of the West Shore R. R. and the latter was cut to enable them to cross it, the line being restored in about an hour without interruption to train service. Three canal boats were secured and being placed side by side parallel with the bank completely filled the channel and provided a sort of pontoon bridge on which and on stringers connecting it with both banks the track was laid and the plant safely moved across. East of Newark the other half of the plant was unloaded from cars on the West Shore R. R. track, on an embankment 6 ft. above the surface of a swamp. A cribwork was built up with ties to the required level and received the cars which were then safely moved across the swamp on a track with the cross ties supported on a grillage of longitudinal ties laid close together so as to cover a surface 8 ft. wide and float the loads.

Most of the small waterways are crossed by box culverts or short span arches, both of which are built of 1:3:6 concrete made with Lehigh or Hudson Portland cement and screened gravel, except for the bridge seats, parapet walls and culvert covers, which are proportioned 1:2:4 and in some unimportant places where it is made 1:4:8.

At Lyons the tracks crossed a pond on a truss bridge of 154 ft. span both piers of which were built in cofferdams made with 2-in. square-edge sheeting plank driven with mauls in lines 2 ft. apart. The cofferdam was built in the winter when the pond was covered with strong ice, which served as a convenient working platform for driving the sheeting. In order to guide the sheeting two lines of 60-ft. rails 2 ft. apart were arranged on the surface of the ice in the lines required for the cofferdam walls. They were braced and securely wired in this position and occasional planks were driven against the rails to serve as guides. The ice was then cut out around the rails and they sunk to the bottom in water 9 ft. deep. The remainder of the sheeting was then driven against the rails, which served as waling pieces, and penetrated through about 6 ft. of mud into the hard gravel bed underlying it.

The space between the walls of the cofferdam was then filled with clay brought from an adjacent cut on the line and thoroughly puddled under water by ramming it with vertical timbers. This made a cofferdam so tight that it was easily emptied by one 6-in. centrifugal pump operated by a traction engine. The interior was excavated to a total depth of 16 ft. about 1 ft. below the surface of the hard gravel, which was considered to afford an excellent foundation. Enough clay was in the mud overlying the gravel to make an almost impervious stratum through which very little water penetrated so that very little difficulty was experienced by water rising through the gravel inside the cofferdam as might have been expected. The bottom of the excavation was carefully leveled and covered with a grillage of 2-in. plank on which the forms were built and the piers constructed of hand-mixed concrete.

A viaduct at Lyons has girder spans resting on monolithic concrete piers extending the full width of the bridge. This construction included 400 yd. of excavation and about 1,500 yd. of concrete aud although the work was not staked out until January 3, 1906, 8 large piers had been completed January 27, as shown in the illustration, pedestal piers 9, 10, 11, 12 and 13 had been commenced, forms were erected for 9 and 10 and concrete was being wheeled to 11 and 12. As this work was done in advance of the track laying it was considered quicker and more economical to mix the concrete by hand on platforms adjacent to the successive piers than it would have been to transport the steam mixer from place to place.

The concreting was continued in zero weather when the water was stored in large tanks in which salt was dissolved in the proportion of 2 ozs. per gal. of water. The sand was heated by piling it around cylindrical salamanders in which coke fires were maintained and salamanders were also placed in the forms on top of the concrete at night. In this way the concrete was satisfactorily laid. Considerable water was encountered in the foundation pits and was removed by a 4-in. centrifugal pump operated by a gasoline engine and by a 6-in. pump operated by a traction engine.

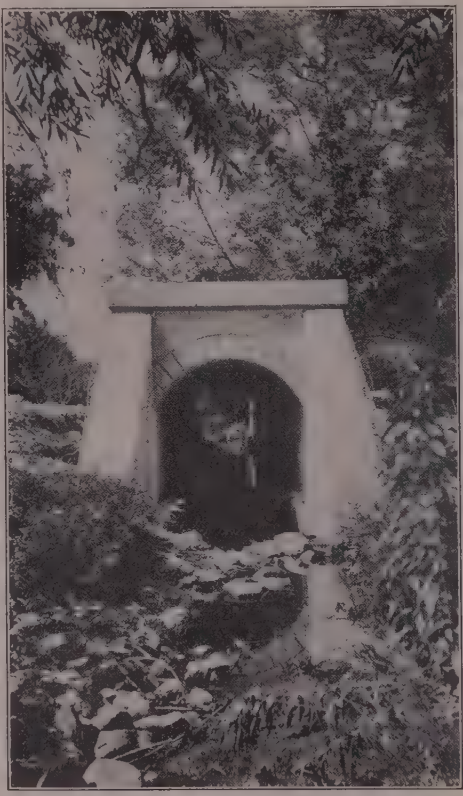
At Newark the tracks are carried across the valley by a plate girder viaduct over the creek and a through span truss bridge over the tracks of the New York Central and West Shore R. R. Here the viaduct columns are supported on 10 pairs of independent pedestals and the main span is carried by large piers, one of which has a 6½x52-ft. base, is 28 ft. high and contains 266 yd. of concrete.

A skew span over the highway near the Blue Cut between Newark and Lyons is made with piers about 18 ft. apart in the clear which support 15-in. I-beams 2 ft. apart on centers, set perpendicular to the faces of the piers. At each side of the bridge an 18-in. I-beam, parallel with the skew, carries the curb and receives one end of the short longitudinal beams which are supported at the other end on the abutment. In each space between the 15-in. I-beams and parallel with them there are two ¾-in. Ransome rods. The bridge floor consists of a solid monolithic slab of concrete 21 in. thick, which encloses the rods and beams and extends 3 in. above and below the flanges of the latter. It is additionally reinforced by seven lines of ¾-in. rods parallel with the abutments. The bridge is 37 ft. wide over all and has a clearance of 14 ft. above the highway. The wing walls are from 19 to 24 ft. long and on one side are in the planes of the abutment face and on the opposite side make angles with it.

East of Palmyra the highway is carried over the tracks by a riveted through truss bridge of two spans supported on two square concrete abutments and on two intermediate vertical columns set in a line skewed with the abutments. The largest abutment has a footing 9 ft. wide above which it is 25 ft. high, and is made integral with the wing wall 80 ft. long at right angles to it.

A small bridge over the tracks about two miles east of Palmyra is typical of the farm crossings where the road is in a cut. Here two pairs of steel columns 28 ft. apart are set one on each side of the tracks, and carry two longitudinal lines of 18-in. 55-lb. I-beams 15 ft. apart on centers. These columns support the ends of wide spans made with 18-in. I-beams 23 ft. long. These girders are web connected to 10-in. 25-lb. I-beams about 4 ft. apart, which carry 4x6-in. longitudinal joists 12 in. apart in the clear. The tops of the joists are flush with the top flanges of the 18-in. girder and with them support the transverse 3-in. floor planks. The ends of the wide spans rest on concrete abutments 4 ft. thick at the base and 2 ft. thick at the top and the columns have concrete pedestals 3 ft. square.

A typical wide flat-top culvert is made with the concrete abutment walls 10 ft. apart and 29 ft. long on their faces. At the ends these walls are deflected 35 degrees for an additional length of 7 ft., forming short wing walls to retain the embankment and sloping at their extremities nearly to the surface of the ground. The side walls support twelve 7-in. I-beams perpendicular to them which together with 22 parallel Ransome reinforcement rods are embedded in the concrete floor slab 12-in. thick. There is 18 in. of fill and ballast between the floor slab and the base of rail which is retained on each side by a parapet wall 2 ft. wide which is made integral with the floor slab and has the upper surface at rail level.



Reinforced Concrete Culvert

Small culverts are made with circular concrete arches of 6, 8 and 10 ft. spans built integral with the concrete side walls. For a 10-ft. span the arch is 18-in. thick at the crown and is made with a radius of 5 ft. 4 in. and a rise of 3 ft. 6 in. It is reinforced by a layer of expanded metal near the intrados and the extrados is made parallel with the intrados for a short distance at the crown and thence is a tangent plane surface to its intersection with the side walls, which are battered 1:8. The latter are 3 ft. 6 in. wide at the springing line, 4 ft. 3 in. wide at the base and 6 ft. high. They are carried on footings 5 ft. 3 in. wide and of variable depths. At the ends of the culverts the spandrel walls rise 12 in. above the crown and are fiuished with a rectangular coping 12 in. high and 21 in. wide which projects 3 in. beyond the face of the culvert. The side walls are continued divergent a short distance beyond the face of the culvert as indicated in the photographs. One of the structures of these dimensions contains about 54 cu. yd. of concrete in the 3-ft. foundations and 44 cu. yd. of concrete in the superstructure.

The culverts of 8 and 6-ft. span have arch rings 15 in. and 12 in. thick respectively and contain above their foundations 92 cu. ft. and 75 cu. ft. of concrete respectively per lin. ft. of culvert measured parallel with its axis. The 10-ft. culverts contain 118 cu. ft. of concrete per lin. ft.

Another type of culvert, 6 ft. wide, is made with concrete side walls 2½ ft. thick and 6 ft. high, carrying a solid floor slab 14 in. thick in which are embedded transverse 45-lb. rails 12 ft. apart on centers. In this case the footings, 3½ ft. wide, of the side walls are connected by a horizontal slab of concrete 6 in. thick which serves as a floor for the water channel and prevents the undermining of the walls. The smaller culverts 2, 3 and 4 ft. square inside are made with similar construction except that the thicknesses of concrete are less and that the roof slab is made from 8 to 12 in. thick and is reinforced only by a sheet of expanded metal just above the lower surface of the concrete.

In the towns the concrete in the foundation for the brick pavement was mixed by a McKelvey mixer mounted on a truck and driven by a gasoline engine. This was kept close to the point where the concrete was being laid and in many cases deposited the concrete directly in the excavation as it was discharged from the machine without the necessity of transporting it in wheel barrows. The concrete for this work was proportioned 1:4:8 and was made with screened gravel instead of broken stone, which was used in the piers for the railroad bridge. The foundation concrete was finished with the 1-in. surface coat of 1:4 Portland cement mortar.

The above described work is being executed under the direction of Mr. Thomas H. Mather, chief engineer of the Syracuse Railroad Construction Company. The contract for all of the track laying and for 14 miles of the grading was awarded to J. G. White & Company, Mr. T. R. Cummins, superintendent.

Chicago Subway Mail Service.

Mail service in the Chicago Subway was inaugurated Feb. 24, when bags of mail were delivered from the La Salle St. railroad depot to the general postoffice through the tunnels. The regular service will not be commenced, however, until March 10, according to the contract between the tunnel company and the postoffice department of the government. Connections with the tunnel system have been completed at the postoffice and at the La Salle St. and the Union depots, and machinery for automatically handling the mail bags installed at these three places, so that the service between the postoffice and the two depots, or between the latter can be started whenever desired. The mail receiving and shipping rooms at all of the railroad passenger depots in the city are to be similarly connected and equipped, the system of tunnels reaching all of them. The entire mail traffic between the postoffice and the railroad depots, and the exceptionally heavy transfer of transcontinental mail required in Chicago can thus all soon be handled through the subway freight tunnels, relieving the streets of a large number of teams, and at the same time much quicker and more economical mail service provided.

THE USE OF LEADITE in place of lead for making joints in water mains has been tried at Atlantic City with satisfactory results. This material is understood to be a mixture of iron filings, sulphur slag and salt in proportions which are kept a secret. It costs about twice as much per pound as lead but weighs about one-sixth as much per cubic foot, so that its cost per joint is only about one-third that of lead. In using it no calking is necessary, which is a source of another saving.

The Belle Fourche Dam, Belle Fourche Project, South Dakota.

By Raymond F. Walter, Project Engineer, U. S. Reclamation Service.

The Belle Fourche dam, now being built by the U. S. Reclamation Service in the western part of South Dakota, will be one of the largest earthen dams in the United States. It is designed to be 6,500 ft. long at the crest, 115 ft. in maximum height, and will require for its construction about 1,600,000 cu. yds. of materials.

The reservoir to be formed above the dam will have an area of 8,000 acres at high water, and an available capacity of about 200,000 acre-feet, or 65,000,000,000 gallons. With such an enormous storage, and with the attendant possibility of an appalling disaster should a break occur in the embankment, it was essential that the most careful attention should be given to all of the preliminary work of exploration and examination of the dam site; to the designing of the structure and its appurtenances; and to the drafting of a rigid set of specifications adapted to secure the most substantial construction without burdening the contract with requirements liable to increase unduly the cost of the work.

Materials Underlying Dam.—The materials on the dam site were thoroughly prospected, both by open-test wells, and by earth-auger borings, and were found to consist of a very heavy adobe clay overlaying a slaty shale. The transition from clay to shale is gradual, and, as revealed by an artesian-well boring just below the dam site, the shale does not become a hard rock until a depth of several hundred feet is reached. The underlying shale follows closely the surface contours, at a depth of from 20 to 40 ft., as shown upon the profile, Fig. 1.

Aside from occasional gravel pockets beneath the creek bed, the earth is a hard, compact, impervious clay, weighing from 105 to 110 lb. per cubic foot in place when sufficiently dry to be friable. Next to solid rock, a material better adapted to resist the passage of water could hardly be imagined; and as the present creek channel, within the limits of the dam, is to be excavated to the shale and refilled with impermeable materials, it is expected that sepage will be inappreciable.

Materials for Dam.—The soil upon all of the area adjacent to the dam site is similar in character to that just described, with the exception that on the ridges at each end of the dam it is somewhat denser than on the flats, while on the high ground to the south there are found in the soil soluble salts of lime and magnesia to an extent making this material undesirable for use in the embankment. There exists, however, within easy hauling distance many times the required amount of materials, in every way admirably suited for making a large embankment.

Small scale experiments show that about 7 per cent. of water, by weight, is ordinarily required in compacting; and that very thorough ramming or rolling is necessary to break up the small, hard lumps in the soil excavated. In order to insure a homogenous mass the specifications require that the embankment shall be thoroughly rolled in 6-in. layers with steam rollers weighing not less than 200 lb. per linear inch of roller rim.

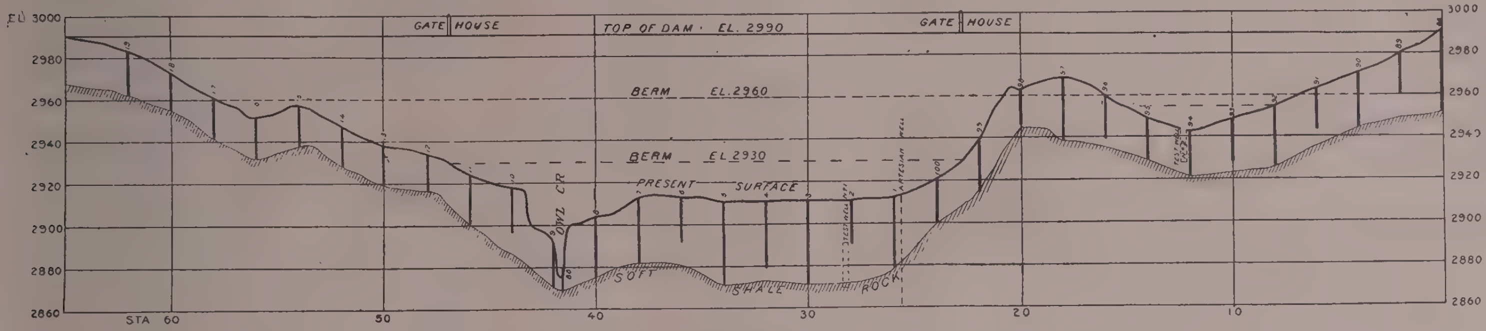


Fig. 1 Profile of Valley at Dam Site.

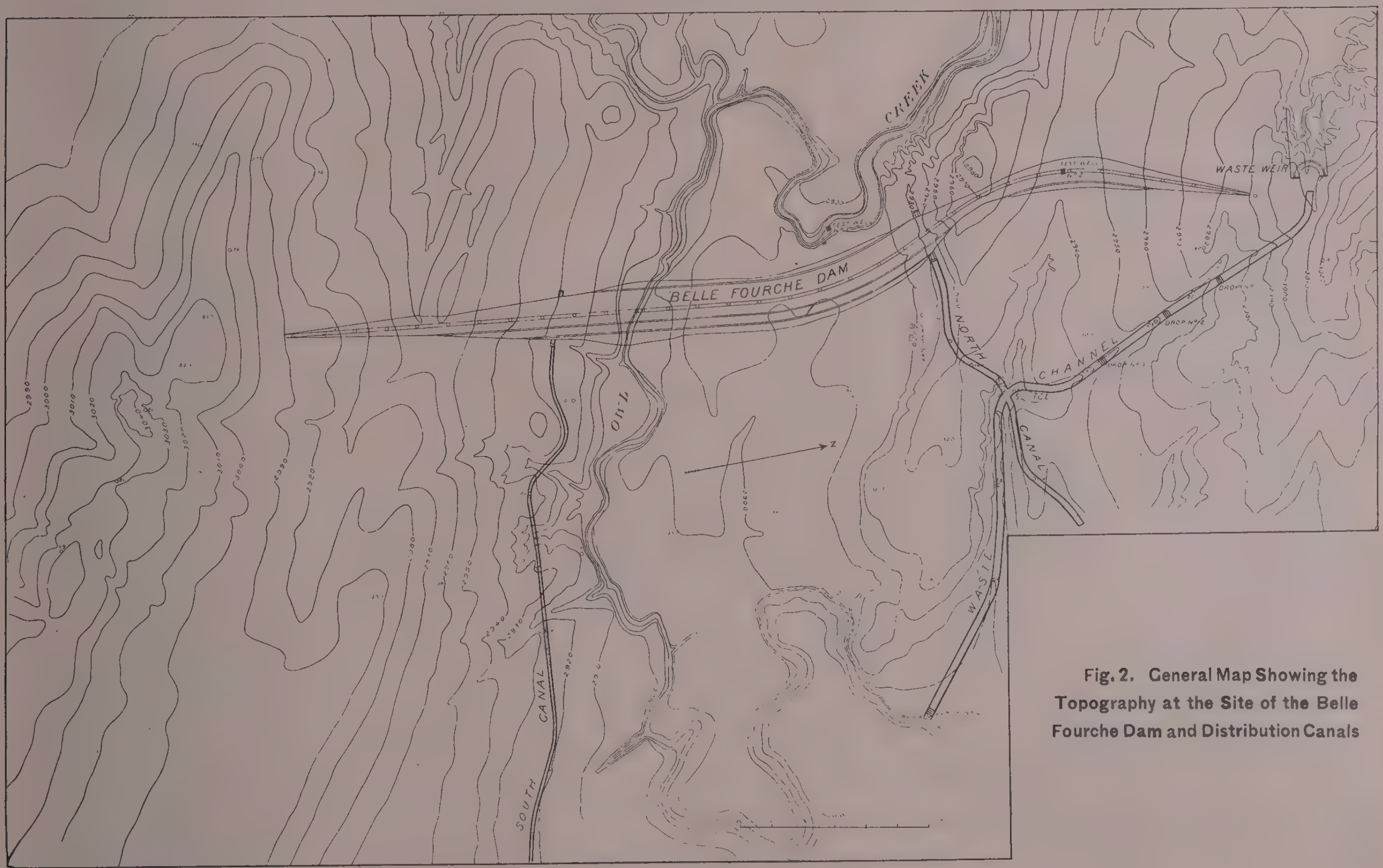


Fig. 2. General Map Showing the Topography at the Site of the Belle Fourche Dam and Distribution Canals

In order to protect the slopes from erosion, the downstream face of the embankment will be surfaced with a 12-in. layer of loam stripped from the site of the borrow areas, and will be sown with varieties of dry land grasses. The upper or water slope will be covered by concrete paving bedded upon a 2-ft. layer of gravel, as hereinafter described.

Plan and Section of Dam.—The alignment of the dam, as indicated by the plan (see Fig. 2), is not straight, but comprises three tangents connected by curves of 4° and 3°, respectively. This form of alignment fits the topography much better than any straight line or curve of constant radius, and, as computed, it also shows a saving of many thousand yards over any alternative location.

The section of the dam embankment (see Fig. 3) has the following dimensions: Top width, 20 ft.; upstream slope, 1 to 1 for 15 ft., or to high water elevation; thence 2 to 1 for 55 ft. to a berm 8 ft. wide, at a point 10 ft. below low water; thence 3 to 1 for the remaining distance. The downstream slope is 1¾ to 1 for the first 30 ft., to a berm 8 ft. wide; thence 2 to 1 for the remaining distance, but with a second 8-ft. berm 30 ft. below the first.

The prevailing slope of 2 to 1 was selected for the following reasons: (1) With the great weight and impermeability of the materials, the section fully satisfies the requirements of stability and water-tightness. (2) Under the intense rainfalls which sometimes occur in this locality for short intervals slopes steeper than 2 to 1 are liable to be seriously eroded. It is difficult to find even short natural slopes which retain a sod on a slope steeper than this. (3) When the embankment material is exposed to standing water, it swells slightly, and becomes very slippery. With the protection afforded by the paving, and gravel on the water slope, it is not anticipated that any softening of the clay surface will be possible. But even in such event a 2 to 1 slope with retaining wall and piling at its foot should be flat enough to hold the paving from slipping.

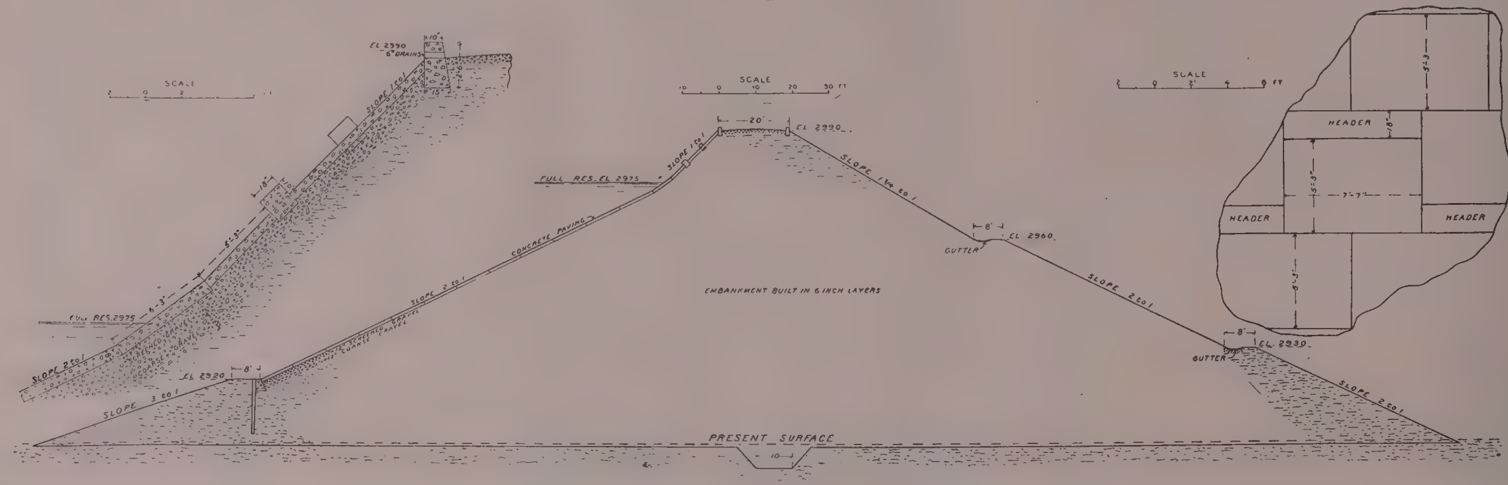


Fig. 3. Detail of Paving, Typical Section of Dam and Plan of Paving

The water slope, above full reservoir level, is made steeper, to better turn the waves, and is provided with a toothed concrete breakwater to further this end (see Fig. 3A). The upper portion of the downstream slope is made steeper than 2 to 1 as a matter of economy in material; for here there is no danger of washing as a result of stoppage or overcharging of the berm drains, and if erosion commence from any other cause, it can be repaired by materials delivered from the roadway at the crest of the embankment. Rainwater drains are provided on the downstream berms, with connecting gutters for leading the rainfall to the foot of the slope.

The upstream berm, after the reservoir is filled, will always be submerged at least 10 ft.; hence the 3 to 1 slope below it, not being subject to wave action, will be left unprotected, except for such temporary protection as is required during the filling of the reservoir. This slope will be reinforced, however, by deposits of waste materials not included in the section of the dam embankment.

Paving on Upstream Slope.—The stretch of open water above the dam will vary from 2 miles in length at low water to 8 miles at full reservoir level; the long axis of the reservoir being in the direction of the prevailing winds. With such an opportunity for violent wave action in addition to the great thrust from the winter ice sheet several feet in thickness, the paving must be able to withstand the most severe punishment without danger of failure.

Whatever the character of the wearing surface, be it stone or concrete, it must be bedded on gravel, rather than on the clayey soil forming the body of the embankment. The nearest quarry from which suitable paving stone can be obtained is 20 miles by rail from Belle Fourche, or 32 miles from the dam site. The stone is a sandstone of medium hardness, and not of a desirable quality for use as paving on such an exposed site. An extensive deposit of hard, clean gravel and sand was found about 6 miles from the dam site, hence concrete was selected as being the best and most economical paving under the circumstances.

Having decided upon the use of concrete, studies and estimates of cost were made for large sheets of reinforced concrete, and for thicker and smaller plain concrete blocks, both made in place upon the slope; also for plain concrete blocks of about 3,000 lb. weght, to be made at a permanent mixing plant and, after seasoning, to be placed upon the slope by movable derricks, as the work progresses.

The latter method was figured as being somewhat the cheapest, and has several decided advantages. The specifications require that after the second season the work shall be conducted so that the reservoir may be kept partly filled, and the storage increased as the dam grows higher. To meet this condition, the paving will have to follow closely the progress of the embankment, and therefore will be placed from time to time in comparatively small lots. This would mean, in the case of blocks made in place, the frequent disorganization of the concrete forces, with the consequent decrease in efficiency, and variation in the quality of the product. Where blocks are made at a permanent mixing plant, they can be manufactured uninterruptedly under uniform conditions for weeks or months at a time; and can be transported by night from the storage yard to the point where they are to be laid, making use of the tracks upon which the dirt trains are hauled during the day time.

Blocks are to be laid with open face joints not exceeding ½-in. in width at any point, and are to be thoroughly bedded upon a 12-in. layer of screened gravel; the latter in turn being supported by a 12-in. layer of natural gravel protecting the earthern embankment. This arrangement provides for thorough drainage behind the paving, without the danger of washing out the sand contained in the lower layer of gravel, or of softening the embankment itself, while at the same time there is no opportunity for ice to get a grip on the blocks, or to crowd them into the backing. If it ever should be necessary to make any repairs, a defective block can be cut out very readily, and can be replaced by one built in place. At the foot of the paved slope will be a concrete retaining wall to distribute the thrust due to the weight of the paving; and where the wall is built upon embankment, it will be reinforced by a line of piles bearing against its lower face (Fig. 4). Above the high water line the concrete is reduced in thickness from 8 to 6 in., and is studded with a double row of projecting headers (Fig. 3 B), designed to break up the waves and to reduce the height to which they will mount the slope. At the top of the paving is a low curb wall containing 6-in. drains at intervals, so that any spray which may reach the roadway will drain back into the reservoir.

Drainage on Downstream Slope.—At intervals of 30 ft., measured vertically, 8-ft. berms have been provided for the downstream slope of the embankment, upon which will be built concrete gutters (Fig. 5), having a carrying capacity equivalent to 1 in. of rainfall collected in 10 minutes from the tributary area.

Reservoir Outlets.—Water for use in irrigation will be delivered through two canals on opposite sides of the valley, having capacities of 650 and 290 cu. ft. per second. The canals are to be served through reinforced concrete conduits (Fig. 6) built beneath the dam embankment in trenches cut in the natural ground; the flow being regulated by rectangular sluice gates (Fig. 7), operating through gate chamber wells to be constructed near the center of embankment.

The reservoir cannot be drawn below El. 2,927, and in practice seldom will be lower than El. 2,930, or 10 ft. above the bottom of the canals. There still will remain about 15,000 acre-feet or 5,000,000,000 gallons in the reservoir when at this elevation, and this amount of storage can be displaced by sedimentary deposits before the useful capacity is encroached upon.

No blow-off has been provided for the lower portion of the storage prism, as it would be practically useless for removing sediment, owing to the large size of the vertical water section, which would dissipate almost immediately the velocity of the outgoing stream.

Gate Houses.—Small concrete gate houses, with tiled roofs, will surmount the gate chambers, and will protect the ball bearing gate stands, stop plank hoists, etc.

As a safeguard, in case of accident to the gates, stop plank grooves have been provided on the upstream side of the latter (Fig. 8 *S*). Stop planks will be made in panels 4 ft. high, of oak weighted with iron to make them heavier than water. They will be stored at all times in the gate houses, ready for placing with the help of a 2-ton chain

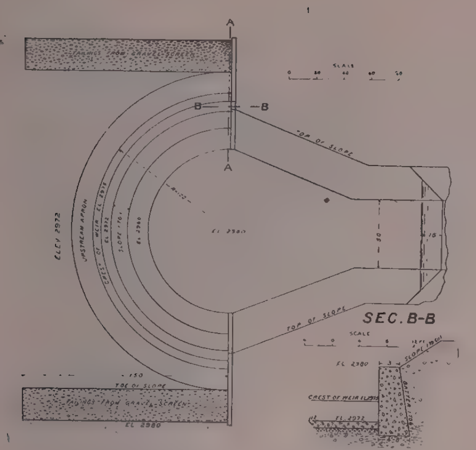


Fig. 10. Waste Weir

hoist (Fig. 9), and trolley, to be installed in each gate house.

Waste Weir and Channel.—A semi-circular concrete waste weir (Fig. 10) is to be located in excavation a few hundred feet north of the dam. Its crest, 300 ft. long, will be 15 ft. lower than the top of the embankment, and under a little more than 2 ft. head can pass floods of 3,000 cu. ft. per second. The difference in elevation between the crest of the waste weir and the creek channel below the dam is about 100 ft. In addition to a 15-ft. drop at the weir, this difference in elevation is overcome by five drops in a channel about one mile long, and wholly in excavation.

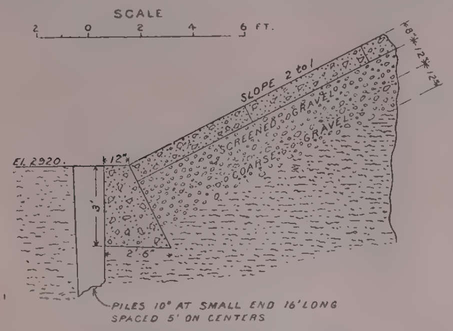


Fig. 4. Detail of Footing

The drainage area of Owl Creek above the dam is about 170 square miles, from which a maximum flood discharge of 3,000 cu. ft. per second is possible. The drainage area is a very flashy one, however, and for the larger part of the year there is no running water in the creek. After a severe storm the creek will flow in large volume for a short period, dwindling to nothing in a few days, the maximum rate prevailing for but a few hours.

The water supply for the reservoir is from the Belle Fourche River through a supply canal (Figs. 1 and 2), 6½ miles long, which will carry 1,635 cu. ft. per second, or about 3,300 acre-feet in 24 hours. This can be shut off when the reservoir is full at short notice.

So great is the storage capacity in the upper portion of the reservoir prism, that for nearly three days it would take a continuous flow of 3,000 cu. ft. per second before the surface would be raised the 2 or 3 ft. required to discharge that amount through the waste weir. A long-continued flood of this volume could undoubtedly not be

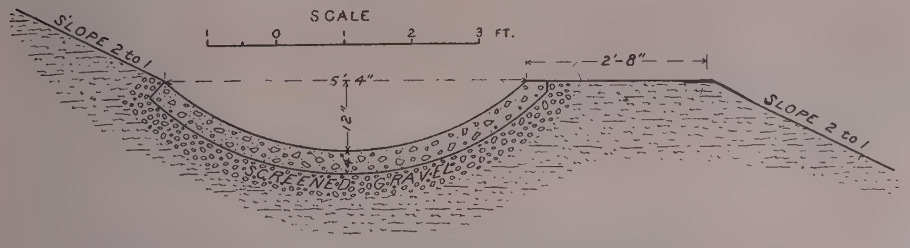


Fig. 5. Profile of 8-ft Berm Containing Gutter

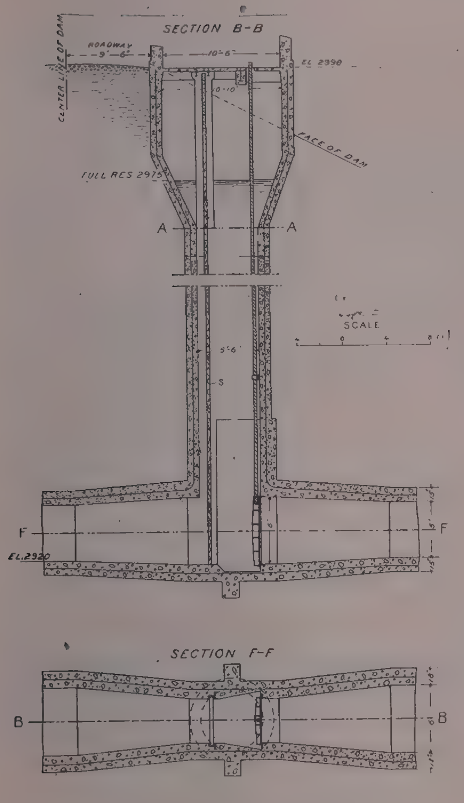
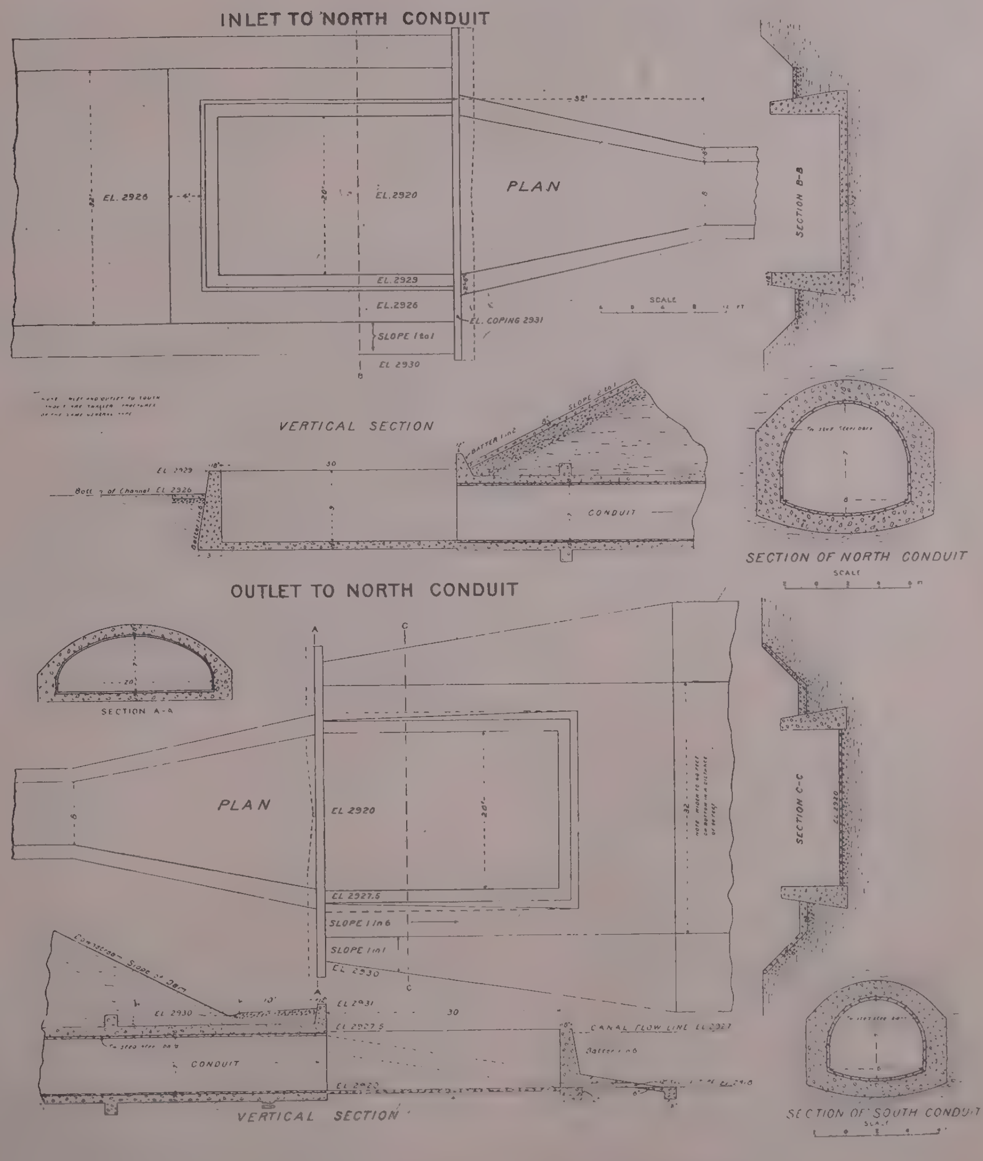


Fig. 8. Section of Gate Chamber



Figs. 6 and 7. Details of North and South Outlets

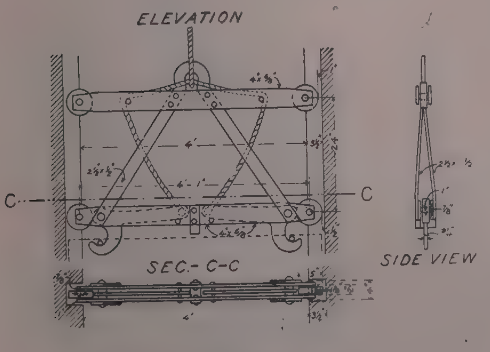


Fig. 9. Stop Plank Lifter

caused by Owl Creek; but it has been assumed that for a time the full capacity of the inlet canal, 1,635 cu. ft. per second, may be augmenting the flood flow of Owl Creek. Under such conditions the flow provided for may be encountered, but the flow certainly can never exceed the safe capacity of the waste weir and waste channel.

Specification Requirements.—In addition to the details of construction already noted, the following are some of the important requirements: The entire area beneath the dam embankment will be plowed, after having been cleared of all brush, weeds and roots; and all pockets of mud or silt will be removed, as well as the material in the present creek channel. A center cut-off trench will then be excavated to a depth of not less than 5 ft., and of a width sufficient to admit of rolling the backfilling with a steam roller. Upon the foundation thus prepared the embankment will be built up in 6-in. layers, the latter having a transverse slope of 3 per cent. draining towards the reservoir, and being subjected to watering and rolling to secure the maximum density.

Work upon the embankment will be discontinued when either the embankment or the materials to be placed in it are frozen, or when the embankment is too wet to permit of satisfactory consolidation.

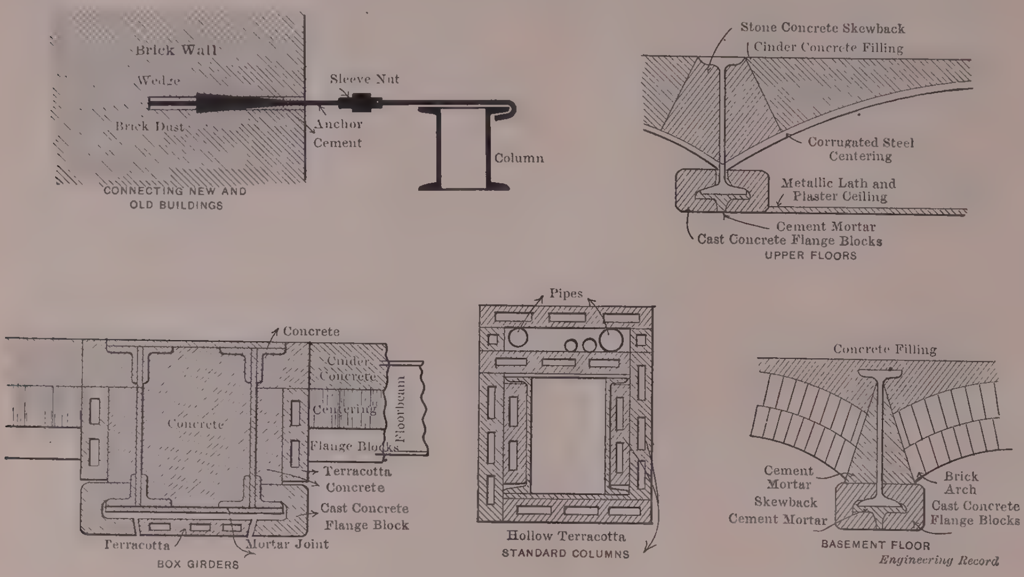
Before placing the loam or the gravel facing upon the embankment the latter will be trimmed to a plane surface, having all loose or uncompacted materials removed; and this work will be paid for as a separate item of the contract.

Four years is the time allowed for the completion of the dam, and the contract price is $879,000.

A Building Trade Suit of more than ordinary interest has been brought in the United States Circuit Court by the National Fire Proofing Co. for an injunction restraining the Master Builders' Association from conspiring with a number of bricklayers' unions to drive it out of business in New York City. These parties have made an agreement, it is said, forbidding the subletting of fireproofing work "if the labor in connection therewith is bricklayer's work as recognized by the trade." Another clause reads: "No member of the bricklayers' union shall work for anyone not complying with all rules and regulations herein agreed to." The result of these clauses, the company states, is to prevent it from putting in its own tiling in the city. It has strikes on ten buildings in consequence, although it employs only union labor and pays full union wages.

Extension of the Metropolitan Life Insurance Building.

One of the largest office buildings in New York City or in the world is that of the Metropolitan Life Insurance Co. at Twenty-third St. and Madison Ave., New York. It now covers the whole of a large city block about 200 ft. wide and 425 ft. long except for one corner which is occupied by Dr. Parkhurst's 75x150-ft. church. A new church for him is nearing completion on a nearby site. When it is finished the old one will be removed, thus enabling the Metropolitan building to be extended over its site and completely occupy the block. This building has been erected in three different sections in as many successive operations covering a period of about 15 years since the first section, known as No. 1 Madison Ave., was built. This portion has an area of 150 x 125 ft. The 115x199-ft. second section was built on Twenty-fourth St. about 9 years ago, and the third section, which completes the block, is now under construction. All the sections have a uniform height of 11 stories above the street level and two stories below it.



Details of Construction in the New Metropolitan Life Building

The Extension of the Metropolitan Life Insurance Building, New York

On the opposite side of Twenty-fourth St., detached from the Metropolitan building, there is a 75x100-ft., 16-story building, with three marble facades, which was designed as a printing house for the exclusive use of the Metropolitan Insurance Co. It is of exceptionally massive steel cage construction, with all floors proportioned for loads of 350 lb. per square foot, and braced to resist the vibration and stresses from reciprocating printing machinery in every story. It is connected with the main building on the south side of the same street by a double-deck tunnel built of the reinforced concrete construction.

Work has been in continuous progress for the last four years in the erection of the printing house and the last section of the main building, and has employed a maximum force of about 600 men.

All but the first section of the main building is of steel cage fireproof construction throughout and contains about 11,000 tons of structural steel work, 18,000 cu. yd. of concrete, more than 12,000,000 bricks, and about 309,000 cu. ft. of marble from an old quarry at Tuckahoe, N. Y., which was opened over 50 years ago by Mr. A. T. Stewart. All the steel was delivered by trucks in Twenty-third St., and was hoisted into position and erected by three guyed boom derricks of 20 tons capacity, assisted by jinniwink derricks which were easily moved from place to place to handle the lighter members. Ordinary breast derricks, served by the large boom derricks, were also used to handle the stone work in the outer walls. The erection of the steel work in the new portions of the building was not unusual except that the columns of the printing house are extremely heavy, requiring unusually powerful derricks to handle them and were so accurately finished and carefully assembled that all connections were easily made. Very little temporary bracing or displacement of members was necessary, which was fortunate, because the weight and rigidity of the framework were so great that it would have been difficult to deflect it materially.

Some of the erection was, however, difficult and unusual where it was necessary to remodel or reconstruct portions of the work already built. An example of this was afforded by the alterations in the first section of the building, where it became necessary to remove three hydraulic elevators and two stairways and replace them by six new passenger elevators and one stairway. This involved practically removing a 50x50-ft. section of the old building and rebuilding in its place a corresponding structure which amounted essentially to building a 12-story steel cage building inside another building. The framework of the new portion of the building was, of course, carefully connected to and adjusted with that of the old building. This involved some rather difficult and delicate operations since the old structure was of the former type of office buildings in which the heavy brick walls were self-sustaining and also carried the ends of floor beams and girders. This feature necessitated a considerable amount of work in shoring the wall ends of the beams and girders in all stories. During this operation, which lasted 6 months, an average force of 100 men worked 20 hrs. per day in two 10-hr. shifts.

In one place in the first story it was necessary to cut an opening 11½ ft. wide and 15 ft. high through a 3-ft. brick wall to provide an entrance to the post office extension. This wall was 11 stories high above the opening and carried an estimated load of 44,000 lb. per lin. ft. In order to avoid all danger of cracking or settlement in the wall and to properly bridge the opening, the latter was provided with massive steel lintel beams supported on steel columns, all of which were put in service before the opening was made, thus avoiding any danger of leaving the wall unsupported at any time.

I-Beam Lintel and Posts for Opening Cut in Wall.

Vertical slots were cut half through one face of the wall on both sides of the opening and at the bottoms of them new brick foundation piers with large cap stones were placed. On them pairs of 15-in. vertical I-beams were set on steel base plates. They were provided with steel cap plates which were wedged up against the under side of the brick work and the spaces carefully grouted. Corresponding vertical slots were cut in the opposite face of the wall, completing and removing sections through it, and in them two pairs of 15-in. I-beam columns were set adjacent to those already in place, in the manner previously described.

After the columns were thus inserted in the wall a horizontal slot was cut half through the brick work connecting their tops on one side of the wall. In this slot was seated two 15-in. I-beams connected by cast-iron separators and bolts and supported at their ends on horizontal shelf angles reinforced with bearings on the upper ends of vertical distributing angles riveted to the column-beam flanges. The upper flanges of the horizontal beams were wedged against the brick work so as to take a considerable load from the wall above. A corresponding slot was made on the opposite side of the wall and two beams were inserted there as already described thus completing the steel framework around the opening.

The spaces between the flanges of the column and lintel beams were filled with grout until the latter escaped through tell-tale holes left in the beam webs and thus gave assurance that all spaces were completely filled. The brick work between the columns and under the lintel was then removed, completing the doorway. These operations were necessarily rather slow and tedious and occupied four men there about two months.

Another interesting operation was the removal of an interior steel-lined chimney which required new framing in all the flors through which it passed. It was replaced by a new 8-ft. steel stack previously built in the adjoining new section of the building to serve the 3,000-h.-p. battery of Babcock & Wilcox boilers installed there for the power plant of the whole building.

The excavation of the building was carried down into the solid rock where considerable water was encountered which, during construction, was delivered from different pits by steam syphons to one large sump. The sump was drained to the sewer by a large Worthington pump. Advantage was taken of the abundant flow of ground water to use it for the sanitary supply of the building. Large wells were sunk under the sub-cellar and from them the auxiliary supply is pumped to roof tanks, where it is stored for flushing purposes.

The general level of the cellar bottom is about 22 ft. below the street, but the footings for the columns are in many cases carried to bed rock several feet lower, in rectangular pits covered at the bottom with at least 6 in. of 1:2:4 concrete made with Northampton Portland cement. On the concrete brick piers are built up to the bottom of the general excavation where they are covered with a uniform sheet of waterproofing which extends over the whole area of the building and is placed between the piers and the granite pedestals above them which support the columns. The spaces around the piers are back filled with selected materials, and the bottom of the general excavation is covered with a 12-in. layer of broken stone containing a system of subsoil drainage pipes, on which is laid a concrete floor of an average thickness of 12 in. with its surface in the plane of the tops of the granite bases of the columns.

The building is notable not only for the strength and accuracy of its construction, but for the great pains taken to provide a thorough system of protection for all the steel work against corrosion and fire. It was painted in the field by journeyman painters, who took special pains to have the surface thoroughly cleaned and completely covered with paint. All of the exterior walls were carefully damp-proofed after all joints and openings in the masonry had been filled with cement. All exposed steel work was thoroughly covered with 2:1 Portland cement mortar at least ½ in. thick, applied carefully to all portions of the painted surface with a trowel or slushed in behind the brick work. The interior spaces in all lattice columns and box girders were filled solid with concrete and thoroughly sealed with cement grout or mortar. All exposed or bottom flanges were encased in special cast blocks made with Portland cement. The basement, sidewalk and first story floors of the main building have segmental arches made with rings of red brick laid in cement mortar. The other floors are of the Rapp type with Roebling ceilings. Great care was taken to avoid contact between the steel surface and the cinder concrete used in filling over the floor arches. To this end stone concrete was filled in adjacent to the beams and girders before the cinder concrete was laid between them. The printing house floors are made of concrete reinforced with Ransome bars,

Views of Fireproofing Employed for the Steelwork of the Metropolitan Building, New York.

the beams and girders are encased in concrete.

The flange protection blocks for all girders in section three of the main building were made with one part Atlas Portland cement and two parts coarse sand, cast in steel moulds 15½ in. long. Each piece was slotted as indicated in the sketch so as to enclose ½ of the flange. They were put together in final position on the girder and the slot left between them was filled with a very soft 1:2 cement mortar, which adhered strongly to them and fastened them securely to the flange. At each joint between the ends of these flange blocks the regular steel clips and ceiling bars were placed and were not only enclosed in the joint mortar, but served as ties for the cross joints.

The box girders were filled with concrete and their lower flanges were protected by the slotted blocks, which served also to support hollow tiles built up flush with their vertical edges. The spaces between these tiles and the girder webs were flushed with Portland cement mortar. The lower edges of the flange blocks were slightly beveled so as to key with the flat terra-cotta slabs protecting the bottom cover plate of the girder.

Columns were enclosed with 2-in. hollow tile laid with ½ in. of cement mortar between them and the steel. On the sides of the columns additional courses of tile were laid to fill the spaces between the flanges. In most cases pipe lines were run adjacent to the columns outside of the regular fireproofing tiles and were enclosed in extensions of the latter which virtually formed separate ducts independent of the column fireproofing, but arranged compactly with the latter so as to be included in a single rectangular cross section. Wherever pipes and conduits pass through the cinder filling the latter was always replaced by cement mortar, thus avoiding contact between the steel and the cinders.

Where the long horizontal expansion loops of the steam pipes occur in the floors they occupy nearly all of the space between the ceiling and floor lines leaving a thickness of only about 4 in. available for the arch and finished floor. Special construction was necessary for these places and in order to select the most desirable type experiments were made at the site with reinforced concrete slabs 2 in. thick built between steel beams 5 ft. apart on centers and reinforced by T-bars 8 in. apart on centers. One slab was made with ordinary rolled 2x2x¼-in. T bars, and the other slab was reinforced with sheet metal T bars of the Rapp type. The slabs were subjected to a 14,000-ft.-lb. impact test made by dropping a 900-lb. load.

This was applied over two of the rolled T-bars, one of which was considerably bent, and a portion of the concrete 8 in. wide and 30 in. long was displaced. In the case of the other slab, two of the sheet metal T-bars were considerably bent and a 16x24-in. hole was made in the concrete. The load, which consisted of an oil barrel filled with wet sand, did not penetrate the slab in either case. The oil barrel was supported on the edges of two parallel planks set as far apart as possible. The planks being simultaneously tipped over allowed the barrel to drop without obstruction to the slab. The slabs also sustained without injury a dead load of 800 lb. concentrated on one square foot at the center of the span. From these tests it was concluded that floors of this construction would be safe under the impact caused by a 1,000-lb. office safe falling 15 ft., about one story, and the type with the rolled T-bars was adopted.

The steel-frame deck houses on the main roof have walls built of hollow terra-cotta furred with 2x⅞-in. horizontal wooden strips 18 in. apart, plastered with Portland cement mortar and painted two coats of damp proofing before the copper sheathing was applied, thus insuring a perfectly tight, warm and dry structure.

During construction the sidewalks were protected by bridges of unusually large capacity having 12x12-in. vertical posts 9 ft. apart longitudinally and 15 ft. apart transversely, which supported longitudinal caps made with single 12x16-in. timbers or 15-in. I-beams longitudinally knee braced to them with 4x12-in. planks. The vertical posts on Fourth Ave. were about 38 ft. long and at first extended to the bottom of the subway trench. Afterwards they were cut off at the bottom and seated on the roof of the subway structure. Elsewhere they were only about 18 ft. long and were seated on a continuous line of 12x12-in. longitudinal sills. The caps carried 6x12-in. transverse beams at panel points and 4x12-in. intermediate transverse beams 12 in. apart on centers. These were decked with 3-in. planks, making a floor which had a capacity of 1,000 lb. per square foot, and was used for storing large quantities of stone and some steel and other materials. Below it there was a light sloping roof of 1-in. matched boards water-proofed with tarred paper and having a clearance of about 12 ft. above the sidewalk.

Framework for False Ceiling and Girder Fireproofing, Metropolitan Building, New York

During the construction of the last section of the building the upper ten stories of the steel framework, about 275 ft. long, was exposed along Twenty-third St., above the second story of the masonry in the outer walls and remained in this condition from summer until winter. The maximum difference of temperature probably amounted to 70 or 80 degrees and caused the steel to contact so much, about 1¼ in. in total at the top, that it opened the joints in the masonry in the exterior walls between the new and the old portions of the building. In order to remedy this and prevent the concentration of temperature movements from affecting the masonry, the new columns were anchored to the old heavy walls which were very thick and as already mentioned supported themselves and part of the floor loads in the old building. Where the connection was made to the ends of the walls 2-in. horizontal holes 3½ ft. deep were drilled in them at every floor. In each of these holes there was placed a steel bar 1½ in. square at one end and sharpened to a wedge shape point at the other end. The split end of a 1½-in. anchor bolt was driven against this wedge and expanded by it until it exactly filled the hole.

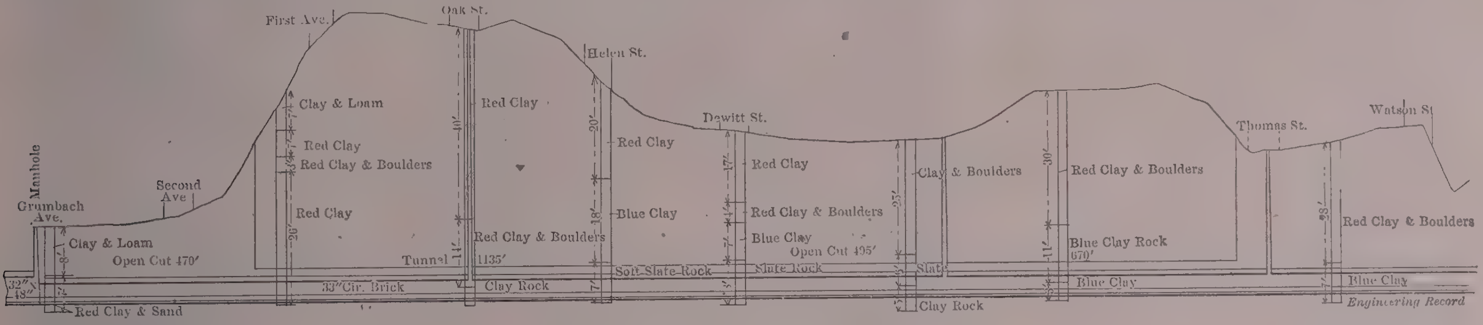
Where the connection was made to the face of the old wall on the inner columns expansion bolts were not necessary, the holes being drilled through the wall and the bolts secured with nuts and washers on its inner face. The outer ends of the anchor bolts were connected by sleeve nuts with hook bolts engaging the columns. The expansion bolts having only ½-in. clearance in the holes, were made to cut their own way into the wall when engaged on the wedge by having their ends sharpened gouge shape. The amount of brick thus cut out of the walls was carefully calculated and the bolts and wedges were made of the exact lengths required to make the space between the square corners at the butt of the wedge and the walls of the circular hole exactly equal to the volume of the brick cut out by the bolt, thus filling the cavity solid and packing the wedge tightly in place. The calculations were so carefully made that when the anchor bolts were driven in with heavy wedges striking on driving cap nuts which protected their outer ends, they penetrated only as far as had been calculated and stopped within ⅛ in. of the marks which had been previously made at the point where they should enter the brick work. There were in all 32 anchor bolts with a calculated strength of 90,000 lb. each.

The original building and the successive additions were designed by Messrs. N. LeBrun & Sons, architects. The general contract was awarded to V. J. Hedden & Sons Co., Mr. J. B. Clermont engineer in charge. The structural steel work was furnished by the J. B. & J. M. Cornell Co., by the Jackson Architectural Iron Works and by Levering & Garrigues. The Reinforced Construction Co. was the contractor for the floor construction and fireproofing in the printing house and for the lining of the tunnel under 24th St.

Tantalum Pens have recently been patented by Siemens & Halske, whose investigations in connection with the tantalum incandescent lamp have furnished much new information concerning this hitherto neglected element.

The Construction of the Tunnel Line Sewer at Syracuse, N. Y.

The tunnel line sewer in Syracuse, N. Y., has been delayed for many years by litigation, but legal obstructions have recently been removed and construction is now under way. This sewer, which is a separate system, takes the sewage of an area of about 600 acres, all sewage and storm water being concentrated at the intersection of Belle Ave. and Teall Ave. The tunnel line takes only the sewage or dry weather flow, carrying it from the concentration point or upper end of tunnel, through a 33-in. brick sewer, part in open cut and part in tunnel, to Grumbach Ave., connecting at this point with the Butternut St. system, which has its outlet in Onondaga Creek. The storm water is carried from the concentration point at Belle Ave. and Teall Ave., through a 66-in. brick sewer, out Teall Ave. to Ley Creek. The tunnel line sewer is entirely through private property, with exception of street crossings, and has a total length of 4,717 ft. From the outlet at Grumbach Ave. it approaches the tunnel proper with 470 ft. of open cut, followed by 1,135 ft. of tunnel, 495 ft. of open cut, 670 ft. of tunnel, 1,240 ft. of open cut, 280 ft. of tunnel, and then 431 ft. of open cut to the intersection of Belle Ave .and Teall Ave. It was the judgment of the designing engineer that in cuts under 30 ft. it would be cheaper to work in open cut than tunnel, and the original plans were made on this basis, but the contractor has decided that if present conditions continue he will build the distance of 495 ft. between the two longest tunnels in tunnel construction instead of open cut, as originally designed. All tunnel openings are permanent, that is, manholes are built at these points and are also placed where the tunnel line intersects streets, at distances of about 600 ft. apart. Work on the open cut sewer from the outlet at Grumbach Ave. was commenced Dec. 2nd. The cuttings ran from 13 ft. at Station 0 to 32 ft. to sub-grade at the tunnel opening or Station 4 + 70.



Profile of Tunnel Sewer, Syracuse, N. Y.

The method pursued through the open cut was ordinary sewer construction, the first 6 ft. being cast by hand and from this point to sub-grade the material handled with a trenching machine. This machine was built by Mr. Thomas Marnell, the contractor, and consists of a track extending over the trench, spiked to cross ties laid on the ground. The rails are laid just inside the line of trench, so that a bucket car clears the sheeting. The bucket car is a rectangular frame of wood mounted on wheels, with a device at the top for hoisting the buckets, which are the iron revolving dump, ¾-yd. capacity, type ordinarily used with trenching machines. Both the car and hoisting apparatus are operated by a double drum stationary engine, one drum having attached to it a cable which causes the car to move forward and backward upon the track and the other drum of the engine is used to operate a cable which hoists or lowers the buckets. The cable runs from the engine house, mounted on wheels, to an A-frame, and the working distance can be made as great as 200 ft. advantageously. The operator standing on the movable car in full view of the trench and buckets below, signals the engineer to raise or lower buckets or to move forward or backward on the track. Buckets are distributed along the trench and when filled the operator drops an empty one, picks up a filled bucket, carries it backward, dumps the material over the completed trench and is ready to repeat the operation with very little loss of time. In this manner the completed trench is backfilled as rapidly as work is finished. As soon as it is desired to move the machine ahead, rails are laid and the engine house moves forward under its own power, carrying the A-frame also, and when the desired distance is reached the engine house and A-frame are blocked.

The open-cut sewer was completed to Station 4 + 04 on Jan. 4th and the distance from Station 4 + 04 to 4 + 70 was left open to allow engineers to have distance for a backsight to project the line into the tunnel. This will soon be built to within a few feet of the tunnel opening, allowing only room enough to raise and lower buckets. The first material encountered in the open cut was 7 ft. of loam clay and gravel; underlying this was a stiff red clay containing stone and gravel varying in size from pebbles to 12-in. boulders. The sewer is 33-in., two-ring brick, the invert is second-quality paving brick and the arch ordinary sewer brick. The brickwork is laid on a cradle of 1-in. hemlock nailed to 2-in. squared forms, and the cradle is backed with concrete, 3 in. underneath, 6 in. at the spring line and all space below the spring line is filled with concrete.

Tunnel.—The original plan of the contractor was to start the 60-ft. shaft at Oak St. and the shaft at De Witt St. about the same time the open-cut excavation was commenced, and so start the tunnel simultaneously in four sections or headings. Delays prevented sinking the shafts until after work had commenced at the western end of the tunnel or Station 4 + 70, but construction will soon be carried on in four headings.

The dimension of tunnel excavation is 7 ft. 9 in. by 5 ft. 10 in., the material following very closely that shown by borings. The borings spaced about every 300 ft., indicated first red clay, underlying this red clay and boulders and at the grade of tunnel a clay rock and in some instances slate rock. The exception to this is that at some points small pockets of clay and sand were encountered which necessitated very close sheeting. One pocket was about 2 ft. thick, running across the tunnel nearly midway between the roof and floor, leaving the roof a very stiff clay with boulders and the floor for 6 in. above sub-grade, a clay rock containing gypsum.

The clay is stiff, but disintegrates from moisture and exposure, requiring side bridging. The material drills easily and so far hand drilling has been used exclusively. At first four holes were drilled in the face, spaced about a foot from sides, the two upper ones 18 in. from the roof, the lower ones from 18 in. to 2 ft. from floor, and each hole loaded with one stick of 60 per cent. dynamite, all four holes being blown at once. This threw down the whole face and was very effective, but was found to be too heavy for the timbering to stand safely, and now the two upper holes are loaded with 1½ sticks and fired, and after the muck is cleared away the two lower ones are loaded with same size charge and fired. The result is satisfactory.

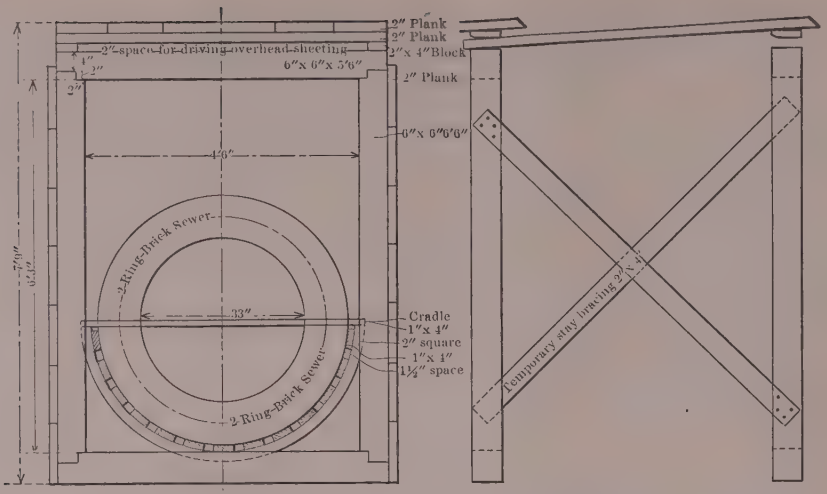
The depth of holes varies from 2 to 2½ ft. The face is thrown out to a depth of 18 in. to 2 ft. at each blast.

All timber used in the tunnel is beech and consist of 6 x 6-in. frames, spaced about 5 ft. centers, as shown on the sketch. The cap and sill are 5 ft. 6 in. long and uprights are 6 ft. 6 in. long, with the corners temporarily strapped with angle iron, which is withdrawn after the overhead and side bridging has advanced two frames. On top of frames at either corner are 2 x 4 x 6-in. blocks, on which are placed 2-in. planks, thus leaving a 2-in. space for driving the top bridging. Owing to the fact that each successive overhead sheeting or top bridging offered a pressure to the plank placed on the blocks, the edges of the plank were beveled and the top bridging pointed, to allow the top bridging to enter the space, and after once entered, the driving progressed satisfactorily. The beech timber, on account of its toughness, does not splinter or brush, as is the case with most other available material.

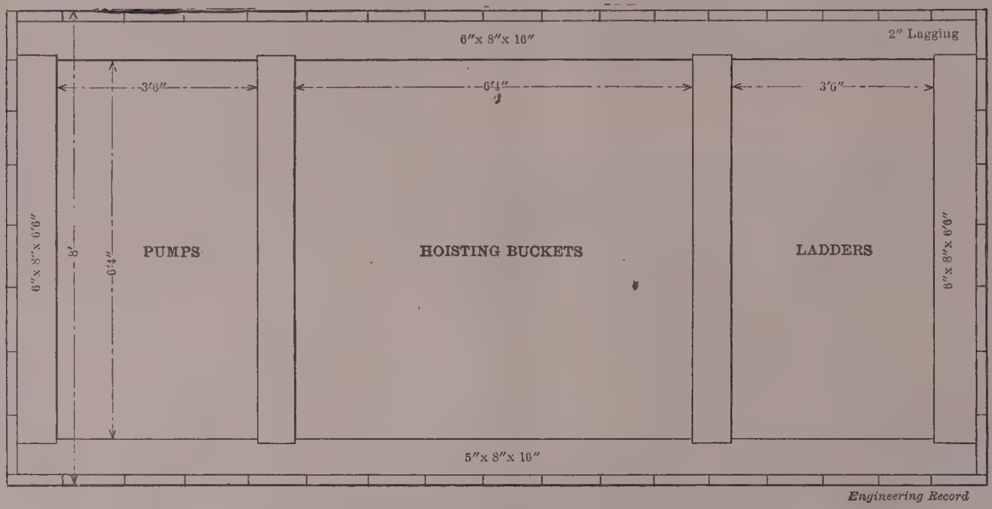
In the tunnel is an 18-in. gauge track, carried along as tunnel progresses, on which runs a flat wooden truck or platform car, sometimes called "go-devil," on which are placed the buckets, similar to those described in the open-cut work. When a bucket is filled a man pushes it to the mouth of the tunnel where it is raised with the same trenching machine described under the open-cut work, and conveyed to the dumping ground. The land near tunnel opening is low and the excess material is used to raise the grade, making very short hauls. A platform is laid at foot of the face when blasting, and the material or muck is thrown out on this and is more easily shoveled into the buckets than from the ground. The low platform car above referred to is also used to carry lumber and materials into the tunnel and in carrying out boulders, etc.

The tunnel is lighted by electricity, furnished by the local lighting company.

The working force consists of three eight-hour shifts of four laborers and a foreman. Sewer construction is the same as in open cut, or 33-in. two-ring brick sewer, laid on a cradle, all the space below the spring line being filled with 1:3:7 natural cement concrete. From spring line of the sewer to the roof of the tunnel is backfilled with earth. The progress made in the heading has averaged 3.4 ft. per eight-hour shift. The excavation is 45.18 cu. ft. per foot of tunnel, or 5.69 yd. per shift. To break this down requires about 12 sticks of 60 per cent. dynamite. The lumber runs about 200 ft. per shift. The labor is: engineer, who also repairs tools during his leisure time while the laborers are drilling; one handy man on



Timbering used on Syracuse Sewer Tunnel.



Plan of Shaft used on Syracuse Sewer Tunnel.

top, who acts as conductor on the car, levels the dump, and assists in cutting frames; two sheeters, two muckers, both sheeters and muckers work at drilling, and one foreman.

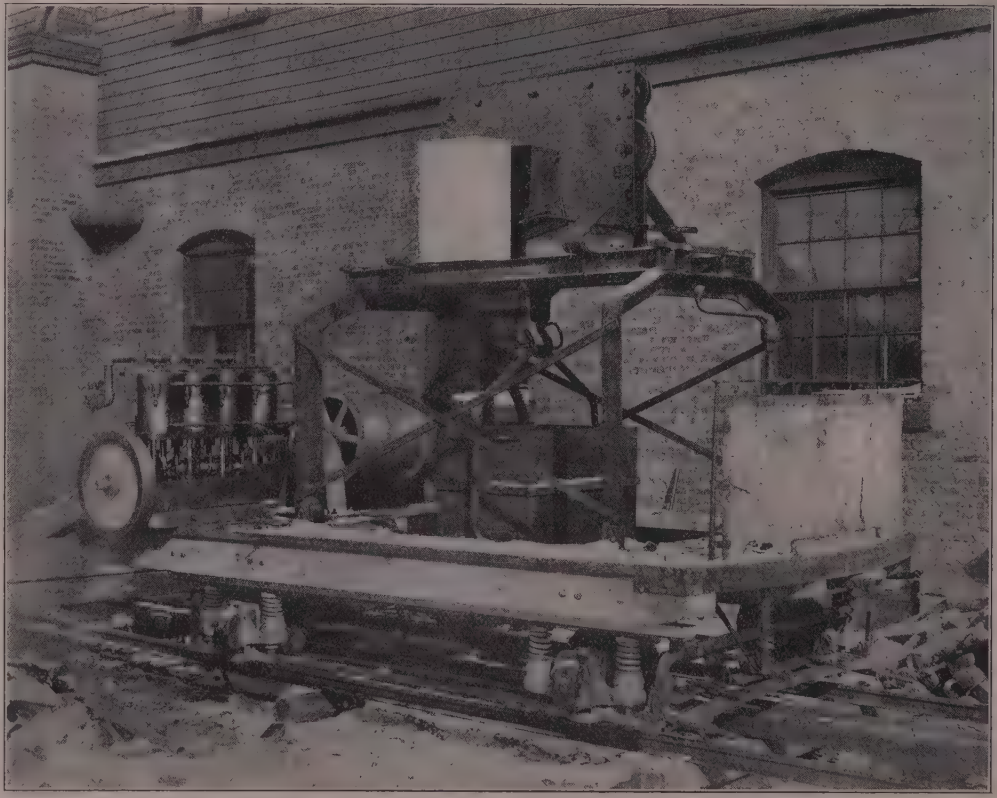
Shaft.—The shaft at Oak St. is 60 ft. deep from the surface of the ground to the sub-grade. The dimensions are 16 ft. 4 in. by 8 ft. and borings at this point indicate 40 ft. of red clay, underlying this is 14 ft. of clay and boulders, and from this point to sub-grade is clay rock. The clay is hard but decomposes with exposure, necessitating close sheeting of sides, or lagging. The shaft is divided into three compartments or openings. The middle opening is 6 ft. 4 in. in the clear and the end openings 3 ft. 6 in. in the clear. The middle opening is used for hoisting the buckets, one end opening for a pumpway and other for a ladderway. The timber is beech and the sets or frames are all 6 x 8 in.; the sides or wall plates are 16 ft. long, the braces or buntons 6 ft. 6 in. long, and the lagging is 2 in. beech.

The machine used at the shaft consists of a platform car 13 ft. long by 7 ft. wide, mounted on steel trucks of standard gauge. There is a hole in the platform 4 ft. 10 in. by 6 ft., through which the buckets are hoisted. Over this hole is an angle iron frame, at the top of which is the supporting mechanism or hoisting device for raising and lowering the buckets. This mechanism is the same as that used on the trenching machine before described. The power to operate the hoisting apparatus and move the car is developed by a four-cylinder, four-cycle, gasoline engine of 30 h.p., acting through a two-way friction clutch; one way this throws in a single drum and operates the cable which hoists or lowers the buckets, and the other way throws in gears connected to the sprocket on the car wheel, causing the car to move forward or backward, the direction being controlled by a marine reversing device. Between the bucket opening and one end of the car is a space of 2½ ft. where the bucket operator stands. At the other end of the car is located the engine and drum, and the engineer is stationed near the opening where he can operate the levers, and at the same time have a clear view of the shaft below, being ready at once to stop the bucket, if for any reason this is necessary. The advantages of this machine over most other forms appear to be in its compactness, and the fact that the engineer and bucket operator both have an unobstructed view of the shaft or trench. The machine was designed and built by Mr. Thomas Marnell, the contractor on this work.

The manhole to be built at the shaft will be 5 ft. in diameter, with a 1-ft. wall of brickwork to within 20 ft. of surface, when the brickwork will be reduced to an 8-in. wall, and 5 ft. from the surface will be drawn in from 5 ft. to 2 ft. in diameter for the iron cover. According to specifications, "the filling at the shaft will be first-class Portland cement concrete. The Portland concrete will be carried to the top of the normal tunnel excavation line. Above the concrete the filling will be made from the material excavated when suitable for the purpose."

The contract prices for the work are as follows: Earth excavation in open cut and disposal of material by removal or refilling trenches, $0.30 per cu. yd.; rock excavation in open cut and disposal of material by removal or refilling of trenches, $1.00 per cu. yd.; all brick masonry, including centers and forms and all incidental work, $3.50 per cu. yd.; first-class Portland cement concrete, $4.00 per cu. yd.; second American cement concrete, $2.75 per cu. yd. All excavation, including rock, to sub-grade of sewer in tunnel and shaft, and disposal of material, $6.00 per cu. yd.; back filling in tunnel and shaft, $1.00 per cu. yd.

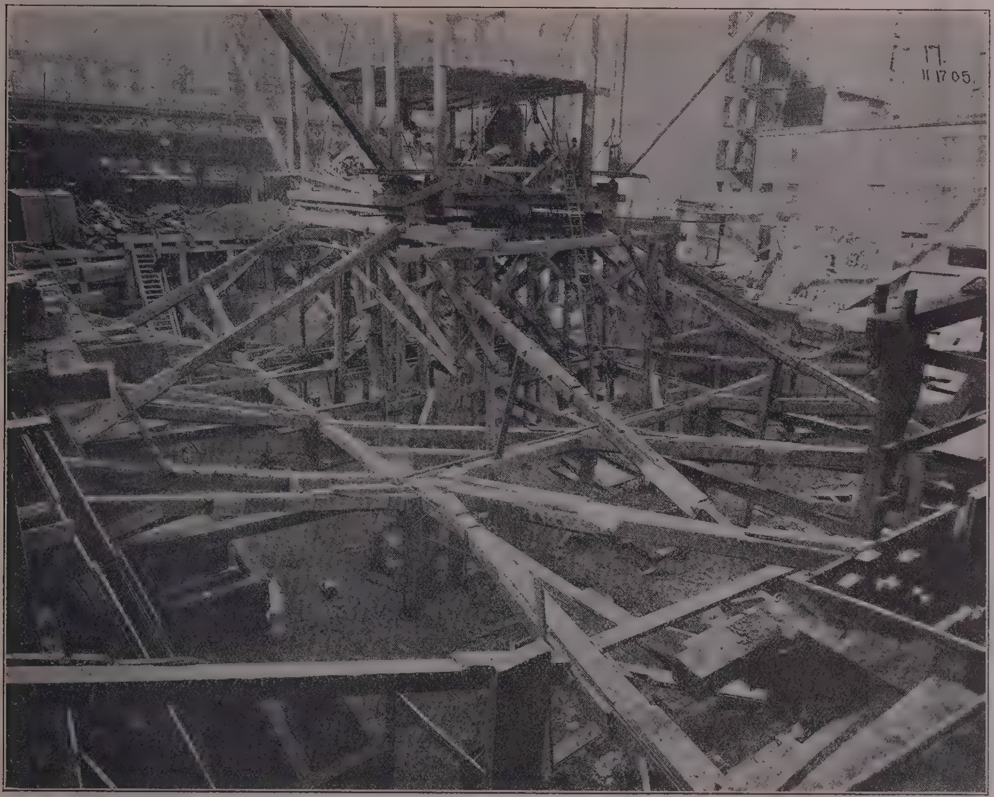
The sewer is under the general charge of Mr. Frank J. Schnauber, city engineer, and is being built under the direction and personal supervision of Mr. Henry B. Brewster, assistant city engineer.



Gasoline Operated Car for Hoisting Spoil from Tunnel Shaft.

SUBSTRUCTURE FOR THE UNITED STATES EXPRESS COMPANY'S BUILDING.

The 134x119-ft., twenty-three story building on Greenwich St., New York, for the United States Express Co., is a steel cage structure of the modern office building type which is now under construction. It has involved considerable difficulty in the building of the substructure where unusual methods were adopted and some special development occurred in the operations found necessary to carry the heavy foundations through water and quicksand to the underlying bed rock at an average depth of about 41 ft. below the lowest point of the curb. Some new features were introduced in the design and method of sinking the foundations, in the joints between the wall piers, in the temporary bracing of the retaining walls, and in the method of handling materials. The retaining wall has a uniform thickness of only about 5 ft. and is of solid concrete without reinforcement bars. It therefore has neither strength nor stability to resist unaided the possible heavy maximum exterior hydraulic pressure and is designed to be strengthened by the basement and sub-basement floors. The beams and girders will be constructed to take bearing against the face of the wall and act as horizontal struts transferring the stresses from side to side and making the opposite pressures hold each other in equilibrium.



Temporary Bracing for Tops of Wall Column Caissons.

The site was previously occupied by old brick buildings three or four stories high which, down to the street level, were removed by wrecking contractors. A contract for the concrete substructure and general excavation was awarded to the Foundation Co., of New York, which was required to complete the work ready for the erection of the steel columns in 100 days. They commenced operations on August 1, five days before the wrecking contractors completed their work. They found the site filled nearly to street level with bricks, mortar and rubbish and excavated it by hand over the entire area of the lot to a depth of about 8 ft. below the low curb carrying the pit to a point just below the old cellar floors. The materials were removed by carts driven up a temporary wooden inclined plane to Greenwich St. The soil consisted of about 9 ft. of earth, loam and fill and an average of 18 ft. of quicksand overlying a stratum of hardpan 14 ft. thick which contained pockets of quicksand and covered the approximately level surface of sound hard rock.

As the column loads were heavy it was determined to carry their foundations down to footing on the rock by means of pneumatic caissons. As it was required to provide a deep substructure with the cellar floor about 20 ft. below the curb and 15 ft. below ground water line it was decided to adopt substantially the same construction that has been described already in these columns for the Stock Exchange, and the Blair Building, namely, to make the piers for the outer wall columns long and narrow and connect them together so as to form a continuous heavy wall down to the rock to make a dam excluding water from the interior.

The 16 regular wall piers have a uniform width of 6 ft. 4 in. and vary in length from 20 ft. 3 in. to 35 ft. 4 in., nearly all being of the latter dimension. They are placed 6 in. to 11 in. apart in the clear end to end, in the planes bounding the basement excavation, thus completely enclosing it. The 27 interior column piers are from about 5 ft. to 8 ft. square, and are arranged from about 15 ft. to 23 ft. on centers approximately at the intersections of 6 longitudinal and 6 transverse lines.

Near the center of the lot 26 piles in five rows from 12 to 15 ft. apart were driven to hardpan 10 ft. below the bottom of the final general excavation, and capped with transverse beams. On these, longitudinal stringers 26 ft. apart, each made with two 12x12-in. timbers bolted together side by side, were placed making a track about 57 ft. long on which a traveling derrick was seated at street level. This was a new derrick, but essentially resembled that previously described in this journal which was used on the substructure of the Trinity Building. It had a 26x26-ft. wooden tower 30 ft. high with wooden sills at the top and bottom and two wooden vertical posts at each corner. The vertical and horizontal faces were each X-braced by pin-connected diagonal rods with sleeve nut adjustments. All of the compression members were pin-connected through jaw plates bolted to each piece thus enabling the framework to be assembled or taken down with great ease and rapidity.

The tower was mounted on eight double-flange wheels seated between the double members of the longitudinal sills and running on the 26-ft. gauge track. Between the vertical posts in each corner of the tower there was set a vertical mast with a 50-ft. boom of 15 tons capacity. Each of the four booms was operated by an independent double-drum Lidgerwood hoisting engine with turning gear to swing it by means of a steel bull-wheel at the foot of the mast. A special feature of the fittings was the seat for the foot of the mast which was made with two heavy bent channels providing an offset attachment for the sheaves that made them accessible at all times. The hoisting engines were located on a floor laid across the bottom sills of the traveler and were protected by a flat roof about half way between the top and bottom sills, which enabled the engines to be comfortably operated in stormy weather.

This traveler commanded all of the interior piers, all of the wall piers on one side of the lot and half of those at each end. The remainder of the lot was commanded by two stiff-leg derricks with 50-ft. 15-ton booms. One of them was seated on cribbing in the excavation and the other was first seated on the sidewalk and afterwards moved to a position on top of the caissons already sunk. Together the six booms of these derricks and of the traveler commanded the entire area of the lot and handled not only the materials and machinery, but unloaded and located the caissons themselves.

Each derrick was supplied with an independent hoisting engine rated at 30 h.-p. There was besides one 80-h.-p. McKiernan air compressor, and one 80-h.-p. Rand air compressor, which, together with a number of steam pumps made a total of about 415 h.-p. plant installed on the work. It was operated by steam at 90 to 100-lb. pressure, purchased by meter from the New York Steam Co. This arrangement was considered more economical than the cost of fuel plus the cost of wages for operating boilers, and had the additional advantage of economizing space which was very much crowded during the sinking of the caissons.

Simultaneously with the erection of the derricks, working platforms of 3-in. plank supported on trestle bents were built at street level to facilitate the delivery and storage of materials. One of them just inside the wall caissons was about 144 ft. long and 16 ft. wide parallel with the Rector St. curb and located over one row of interior column piers. It had a smaller extension on one side reaching to the traveling derrick platform and one of 35 x 14 ft. on the opposite side reaching across the wall caisson to the curb line. Another platform about 80 ft. long and from 16 to 46 ft. wide, at right angles to the first one formed an L with it and extended from the curb line over the second row of interior columns parallel with Trinity Place; both of these platforms were somewhat irregular but corresponded substantially to the above dimensions. They covered nine interior column caissons and all or part of four wall column caissons, holes being cut through them to sink the latter as required and afterwards covered over again to maintain the working platform. Along one side of the lot opposite Rector St., were built one-story weatherproof wooden houses for the compressing machinery, for the carpenters, and riggers, for tools, for the master mechanic, and for sand hogs.

The wooden pneumatic caissons were rectangular boxes of a uniform height of about 6 ft. intended solely for working chambers. All of them were narrow, their maximum length was about 35½ ft., and they were built complete at the contractor's yard and delivered on wagons to the site. The heaviest one weighed about 10 tons and was well within the capacity of the derricks. As received, each caisson was unloaded and swung into position by a derrick boom which lowered it to the exact position required where it was lined in by a transit and seated on the leveled ground. The caissons were delivered rapidly, and sunk to exclude the water as much as possible from the lot, while the interior column piers were being built. Sometimes as many as four caissons were delivered in one day, and half of them were in different stages of sinking simultaneously.

The wall column caissons were of special design adapted to the conditions and requirements of this work. They were all built with a uniform width of 5½ ft. and a height of 6 ft. over all, the lengths varying from 25 ft. to 35 ft. 4 in. Each of them consisted simply of four vertical timber walls without top or bottom. Each wall was made with six courses of timber with the ends of the transverse and longitudinal timbers overlapping alternately at the corners so as to lock the walls together.

The lower course was made of 8x12-in. timber, and the next four courses with 6x12-in. timber, the 12-in. dimension in all of them being vertical. The upper course was made with 10x10-in. timber and all timber was planed on all sides, making the final dimension ¼ in. less than those noted. The successive courses of timber were fastened by ¾-in. drift bolts 2 ft. long and averaging 18 in. apart. There were besides 1-in. vertical screw rods 3 ft. apart, binding together all the courses of each wall and securing the 6x4-in. angle iron cutting edge to the lower course. The long sides of the bottom courses were braced together by two equi-distant horizontal 6x12-in. struts butted against their inner faces and secured by a 1-in. tie rod on each side. The caissons were not provided with permanent roofs or deck. Instead there were bolted across the top courses single 3x3x¼-in. angles 3 ft. apart, with their vertical flanges upwards. The ends of these angles engaged the vertical tie bolts which secured the cutting edge angles and served as bearing washers for them.

After the caisson was set in position the spaces between the transverse angles were covered with temporary sectional panels of 1⅞-in. tongue and groove boards which served as centering similar to that used in the construction of concrete floor slabs. Simple moulds having the same widths and lengths as the caisson and variable heights were built on top of the caissons to receive the permanent concrete piers. These moulds were made in 8-ft. sections with vertical 2-in. tongue and groove planks held together by outside horizontal yokes each made with 4x3x¼-in. angles forming a rectangular frame accurately fitting the mould. One yoke was placed at the middle of each section and one at the top and one at the bottom with their horizontal flanges serving for connections with the adjacent sections. The opposite walls of the moulds were securely tied together by permanent ¾-in. screw rods.

After the mould was completed a layer of rich concrete about 6 in. thick was spread over the temporary roof of the caisson. After it had attained some bearing strength about 2 ft. more concrete was added, and when it was well set and provided a sufficiently strong slab the remainder of the concrete was rapidly filled into the cofferdam building up the pier to the required height in about four days. A central vertical air shaft 45 in. in diameter was formed in the concrete and the pier was considered completed in its temporary position above the surface of the ground; care being, of course, taken to brace it thoroughly on account of its height and narrow base.

Simultaneously with the concreting in the mould, workmen entered the caisson and trenched it under atmospheric pressure down to about water line, thus allowing it to sink gradually 5 or 6 ft. As the tops of the finished piers were to be sunk below the level to which the site was at this time excavated, temporary cofferdams, similar in construction to the pier moulds, were added to the top of the latter. A Moran air lock was provided for each caisson, air pressure was turned on and the final sinking was commenced with about eight sand hogs in each long caisson.

Owing to the very narrow width and the great length of the caisson the material excavated from the extreme ends had to be passed by three men to the bottom of the air shaft where only two men could work at once in filling it into the ½-yd. special cylindrical bottom-flap buckets by which it was removed and in which the concrete was afterwards lowered to the working chamber.

Ballast Boxes for Sinking Cofferdams.

The stability of the caissons was secured by enclosing them in heavy rectangular horizontal timber frames braced with inclined struts. These took bearing on vertical greased guide strips attached to the faces of the concrete pier after the moulds had been stripped. The concrete itself was not greased, but the caisson and the pier above it descended as easily as do those which have a greased wooden surface. By this method the pier itself was made to suffice for sinking weight on the caisson and considerable economy was effected in time as well as in handling the ballast and placing the concrete.

The caissons were sunk through the quicksand in an average of two days each, two days more being required to pass through the hardpan to the rock. The surface of the rock was carefully leveled, inspected by an engineer, and the working chamber was filled with 1:2:4 concrete made with Atlas Portland cement, the concrete in the pier above being made 1:3:5. Before the working chamber was filled the temporary panels of centering between the transverse angles were removed, leaving the angles themselves bedded in the pier concrete.

The ends of the adjacent wall caissons were sunk with a clearance of from 6 to 12 in., and in order to secure continuity between the piers they were connected after sinking by a concrete joint forming a vertical key. Vertical grooves about 2 ft. wide and 8 in. deep were made in the ends of the wall piers and formed, with the clearance already noted for the caissons, wells from 22 to 28 in. wide above the tops of the working chambers. Compound sheet piles were made with 3-in. planks wide enough to overlap the corners of adjacent piers at each joint and were driven close to the inner and outer faces of the piers so as to cover the joints between them. These piles were stiffened and guided by one or two vertical ribs bolted to them in the space between the ends of the piers.

After the sheet piles were driven 4-in. pipes were jetted down in the corners between their edges and the outer faces of the piers, and as they were withdrawn grout was forced through them which effectually sealed the spaces between the piles and the piers. Men were then able to enter the well between the ends of the piers and excavate the quicksand and hardpan down to the tops of the caissons, caulking as they went any slight leaks between the sheet piles and the piers. Jet pipes from 2 to 6 in. in diameter were sunk in the narrow space between the caissons and removed or loosened the material down to the cutting edges. Grout was then introduced through them and with the sand and broken stone already there formed concrete thoroughly sealing the space between the working chambers. Afterwards the well above the working chamber was rammed full of ordinary concrete, thus making a solid key which united the wall piers and prevented leakage.

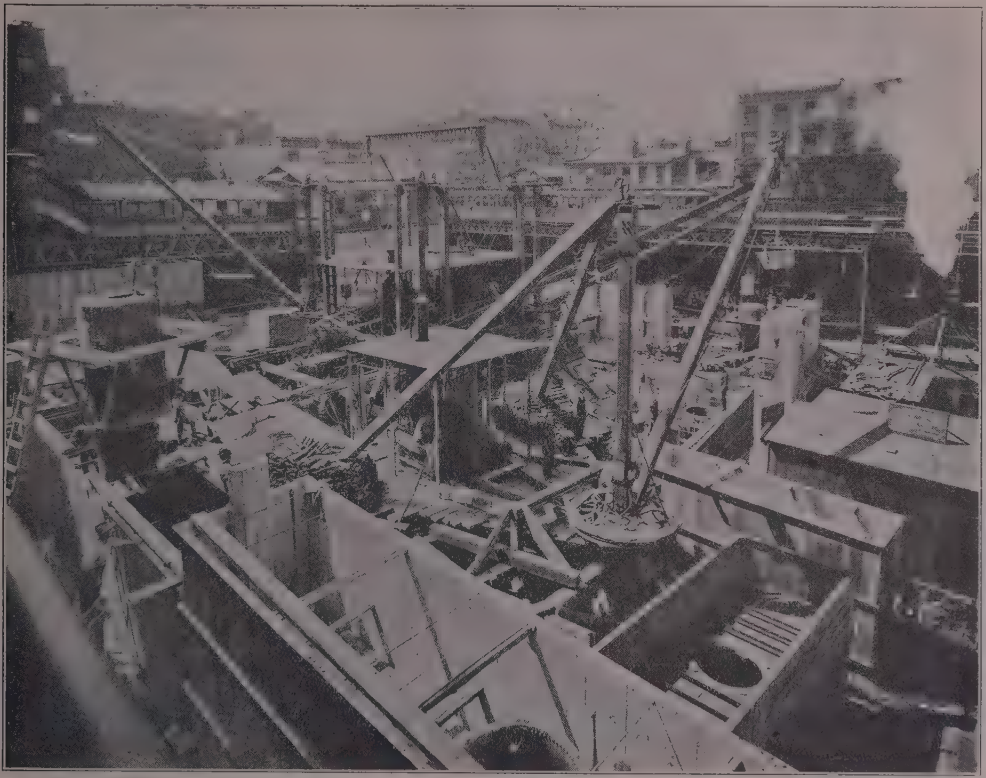
Before the general excavation was completed from the preliminary level of 9 ft. to the final level of 21 ft. below the curb, a temporary system of horizontal bracing was provided to secure the tops of the wall piers and take up the outward pressure until it should be resisted by the permanent steel beams and girders in the lower floors. To this end a 40x50-ft. horizontal rectangular framework of 14x14-in. timbers, divided into six panels and double knee braced in each corner was framed in aproximately the center of the lot, 4 ft. below the level of the top of the wall caisson. It was supported on vertical 14x14-in. square timbers driven by pile drivers to hardpan, and X-braced in vertical planes above the bottom of the excavation. From the center rectangular frame fourteen regular horizontal and inclined longitudinal and transverse braces and two extra ones were carried to all of the wall caissons and firmly wedged against bearing planks on their faces, thus providing for the balancing of all external pressures. Horizontal knee-brace timbers were also wedged against the faces of the wall caissons at the corners and some special struts were placed across the extension of the foundation reaching from caisson to caisson direct.

This system was an entirely independent one, and being supported by the vertical piles did not require shifting, support, or any changes as the excavation under it was carried on. Particular pains were taken to isolate it so that there was no connection with the derricks and their vibrations could not be transmitted to it.

It was at first intended to complete the general excavation before commencing the construction of the interior column piers. As this excavation extends below the surface of the hardpan the pits in which the piers were carried farther to bed rock would not have required sheeting. It was found, however, that the space was so crowded that the removal of the excavated material from the lot could not be accomplished rapidly enough to complete it in time to allow for the building of the interior piers afterwards within the contract time. Provision was therefore made at an added expense of nearly $10,000 for the construction of the interior piers in cofferdams before the excavation was completed, and the work was so executed only to find eventually that after the piers were completed the erection of the steel was long delayed by a strike, and the original method might as well have been carried out.

The cofferdams for the interior piers were all rectangular and from 5 to 8 ft. long inside on each face. They were made in from two to four separate vertical sections 8 ft. high. Each section consisted of four separate panels, each panel making a complete side wall. Each panel was made with 3-in. tongue and groove vertical planks spiked to two intermediate and two end interior 8x8-in. horizontal timbers which were halved, lapped and bolted together at the corners. The end timbers were set back about ½ in. from the ends of the vertical sheathing so as to secure clearance between them and contact on the ends of the sheeting of adjacent sections of the cofferdam when the latter were fastened together by vertical flange bolts through the end horizontal timbers. The lower ends of the sheeting in the bottom sections of the cofferdams projected 18 in. below the lower transverse timbers and were beveled inside to make cutting edges. The panels for the cofferdams were finished complete at the shops and were quickly bolted together in the required position at the site. They were sunk at the rate of about 1 ft. an hour with open excavation by gangs of six to eight men in each who shoveled the material into 1-yd. Steubner buckets.

The spoil both from the cofferdams and the pneumatic caissons was delivered by the derrick booms which either dumped it directly on the wagons in the street or when the wagons were not ready, dumped it on the working platforms, whence it was shoveled to the wagons by hand. The excavation was thus carried on with great rapidity in a number of the cofferdams simultaneously with that in the open space between the cofferdams, and it is believed that the record of about 1,800 cu. yd. removed in 30 hours from Saturday night until Monday morning is greater than has previously been attained in any similar work. Another record for 24 hr. is of 242 wagon loads during the day and 179 wagon loads during the night, all of them averaging 2½ cu. yd. each of dry earth.



Traveler Tower Derricks and Wall Column Caissons

Considerable water was encountered in the cofferdams and was removed by a steam syphon in each, which delivered it to a central sump where it was elevated to the sewer by a Cameron pump. A special feature of the cofferdam sinking was the use of novel boxes to contain the pig-iron ballast used for loading them so that they could be easily and rapidly handled and arranged so as not to obstruct the entrances to the small cofferdams. A large number of boxes were made by bolting together side by side pairs of 12x12-in. timbers 8 ft. long and enclosing them with short vertical 2-in. planks spiked to them on both sides and both ends and projecting 18 in. above their upper surface. A pair of U-bolts with forged eyes on their upper ends engaged the horizontal timbers and afforded connections for hoisting the boxes when they were each filled with six tons of pig-iron neatly piled in them transversely. These boxes were piled up cob-house fashion by the derricks on the upper edges of the cofferdams and gave great satisfaction, obviating the necessity of special platforms or yokes on the cofferdams and greatly expediting the handling of the ballast. A small portable 500-lb. Dake hoisting engine was used to handle the ballast where these boxes could not be used.

As soon as they were sunk the cofferdams were filled with concrete mixed in a Ransome machine and delivered to them by Cyclopean 1-yd. buckets. As they were exposed by the excavation the cofferdams for the interior piers were removed and their panels stored for future use. The cofferdams on the tops of the wall piers were also removed except in some cases where they were allowed to remain on the outer face of the piers to serve as permanent sheeting and retain the earth until the sidewalk vaults are completed.

The bottom of the excavation is covered with concrete laid on the hardpan and assumed to be strong enough to resist the slight upward pressure of water which may penetrate to its lower surface. The floor and walls are all waterproofed by the hydrolithic coating of the Winslow system, which is controlled in this city by the Waterproofing Co., which is affiliated with the Foundation Co. In this process a thin coating of special material is plastered directly on the inner surface of the floor and wall and is claimed to provide a permanent complete waterproofing capable of resisting hydrostatic pressure of 100 lb. per square inch, and of being finished in various colors.

The principal quantities involved in this work include about 20,000 cu. yd. of general excavation, 5,000 cu. yd. of caisson excavation, and 6,000 yd. of concrete. Work was commenced August 1st, the last caisson pier was completed November 7, and the job was entirely finished ready for steel November 15, the work having been continuously prosecuted day and night by three successive eight-hour shifts averaging 150 men each.

Besides the plant already mentioned there was installed a 48-in. x 12-ft. air receiver, a 12-in x 12-ft. tubular Nason air cooler, a pile driver, three Cameron pumps, two Ingersoll-Sergeant drills and about 500 tons of pig-iron ballast. A 20-in. Industrial track, made by the C. W. Hunt Co., was also laid to form a belt line in the excavation around the circumference of the lot on which concrete was delivered from the mixer to the different caissons, switches being arranged at different points for by-passes. By this arrangement a number of cars each carrying a single bucket were kept constantly moving in the same direction and supplied the different derricks without delay.

Two columns of the Manhattan Elevated R. R. structure were so near the excavation that it was necessary to underpin them, an operation which was conducted by the railroad company, who supported the columns temporarily on girders until their new foundations were built to receive them.

Before the general excavation was commenced the adjacent wall of a three-story brick building on the next lot was underpinned with seven 10-in. screwed steel pipes sunk to bed rock and filled with concrete by the Breuchaud method. Two alternate pipes were simultaneously sunk at a rate of about 30 ft. in 24 hr. by the use of a 100-ton hydraulic jack and a 100-lb. hydraulic jet for each. The building was designed by Clinton & Russell, architects, Col. J. H. Wells, structural engineer. The general contract was awarded to the Thompson-Starrett Co., Mr. George Simpson, chief engineer. The substructure work was executed by the Foundation Co., Mr. L. L. Brown, general superintendent in charge.

Excavation on the Panama Canal has lately been progressing unusually well, according to a report sent to the Isthmian Canal Commission by Chief Engineer John F. Stevens. This shows that the volume handled has increased and the cost dropped. "The work report for the month of Jan., 1906, Culebra division, shows a total yardage moved of 120,990, at a cost of 72 cents a cubic yard. Comparing this with the figures for December, the latter month shows 70,630 yards moved at a cost of 93 cents. The above figures are made in accordance with the monthly reports which have been made since the Isthmian Canal Commission took charge of the work, and you will see that, as compared with certain months last fall, we have reduced the cost of handling this material over 100 per cent."

The Reinforced Concrete Factory for the American Oak Leather Co., Cincinnati.

By Sanford E. Thompson, Assoc. M. Am. Soc. C.E.,
Newton Highlands, Mass.

During a recent trip through Ohio the writer was much interested in the progress of reinforced concrete building construction in Cincinnati. At least seven such structures, including warehouses, factories, office buildings and stores, were then in process of erection. The tendency in Cincinnati recently has been to build the exterior walls of brick, and the structural portions of the building, that is, the columns, beams and floors, of reinforced concrete. This is due to economical considerations. Because of the cost of lumber and of the labor of placing and removing wall forms and the necessity of specially treating the face of the concrete, or else veneering it with stone or brick, it is often cheaper to build the entire wall, except the trimmings, of brick.

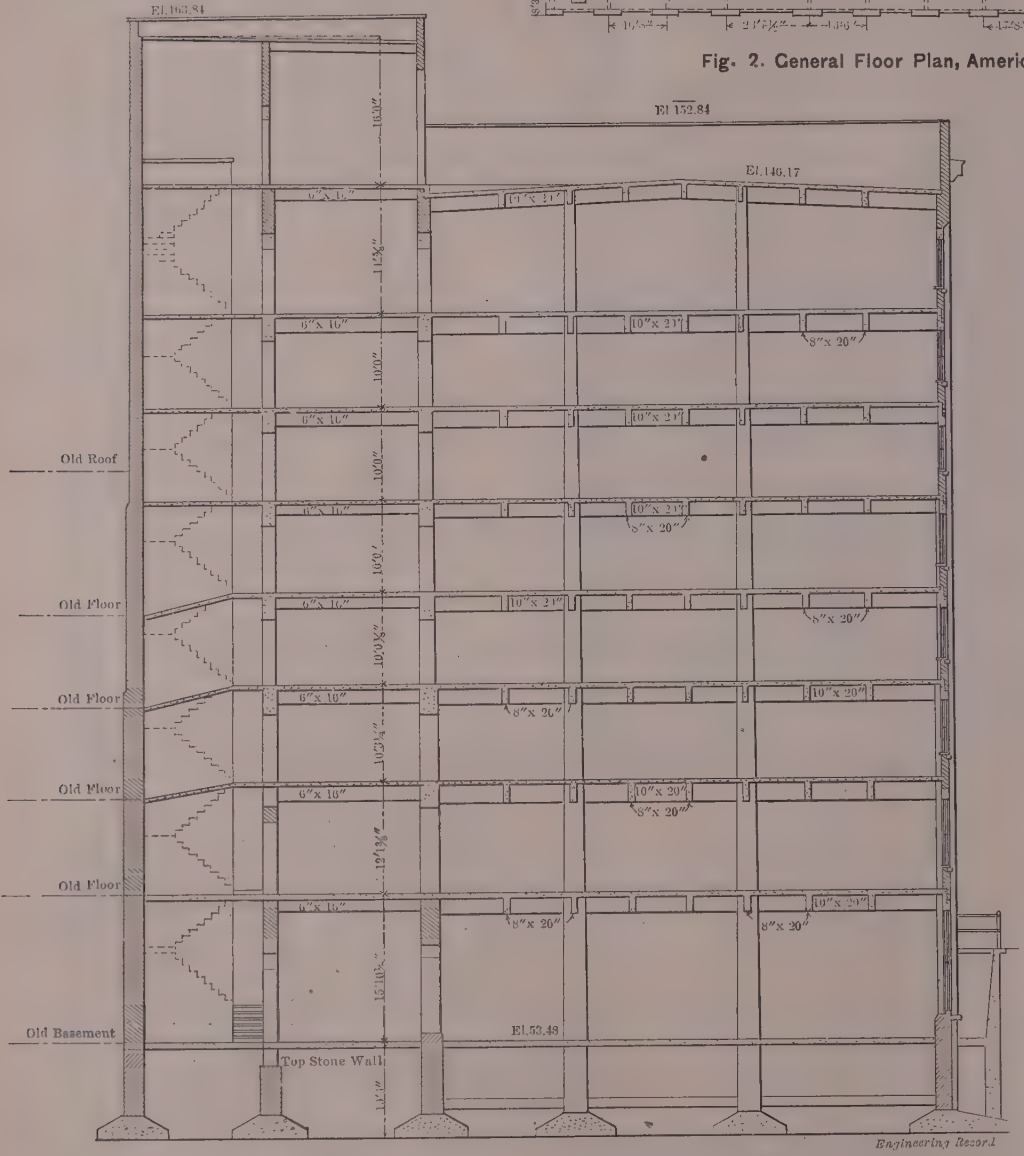


Fig. I. Cross Section of Reinforced Concrete Building of American Oak Leather Co.

Among the pioneers in reinforced concrete construction is the Ferro-Concrete Construction Co., the builders of the famous sixteen-story Ingalls office building and several other structures, including the factory of the American Oak Leather Co., also in Cincinnati. Although the writer has not been connected in a professional capacity with the design or construction of the American Oak Leather Co. factory, the work appeared of sufficient interest to warrant the presentation of some of its structural features to the readers of The Engineering Record.

The building is designed for heavy loading, and in anticipation of the presence of piles of leather on all or nearly all the floors at the same time, this heavy loading was carried through to the foundations. The design of the floor plan and the connection of the building with an old one belonging to the same company required a large variety of sizes of floor panels, each of which was especially designed in thickness and reinforcement for its particular load.

The building is seven stories high above the basement, and the basement floor is full of tanks and vats and troughs, all of reinforced concrete, for use in the operations incident to the preparation of leather.

Fig. 1 is a typical section across the building. The main portion of the structure represented by the three bays at the right is 58 ft. wide by 269 ft. in length. Wings, eight stories high above the basement and projecting at each end of the building as shown in Fib. 2, carry the reinforced concrete stairways and also connect with the old building.

The columns vary in size in accordance with the spans they carry, ranging from 10 x 10 in. to 32 x 36 in. The principal girders, that is, the girders across the building, range in size from 8 x 20 in. to 14 x 20 in. and 10 x 24 in. The longitudinal beams which butt into the principal girders range from 6 x 16 in. to 8 x 20 in. The floor slabs vary with the span from 4 to 7 in. in total thickness.

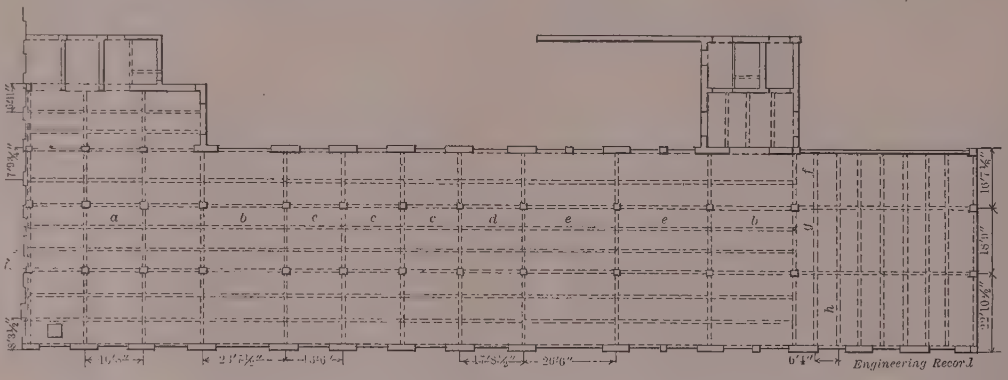


Fig. 2. General Floor Plan, American Oak Leather Company's Building.

For a reinforced concrete building nearly as many carpenters are required as laborers, and one of the first essentials for economical construction is the design of the forms to reduce the quantity of lumber to a minimum, and the construction of these forms at the smallest possible labor cost. In the present case one of the first operations was the erection of a shanty occupying half of the street next to the site, which was fortunately on an unfrequented highway, and equipping it with power saws and other woodworking machinery. Here all the forms required in the construction of the building were made, and the general repairing was done.

Structural Details.—Twisted steel was used for reinforcement. The square rods were twisted, cut to length, and bent to shape at the permanent shop of the contractors in the city. The twisting machine twists three, 30-ft. rods of the smaller sizes, at the same operation. As the operation of twisting a set of three rods occupies two men with the machine but slightly over one minute (not including the carrying to and from the machine), the cost is scarcely appreciable, while the twisting produces a deformed rod capable of greater adhesion and with an increased elastic limit. The high elastic limit was utilized by the designers in the assumption of a higher allowable unit pull in the steel and thus a smaller percentage of the metal in the beams and slabs.

A cutter designed with a multiple lever, so as to be operated by one man, cuts single rods up to ⅞ in. square, and smaller rods in lots of two or more.

All rods are bent cold. The small rods up to about ⅜ in. square, which comprise all the steel which requires bending except the bent bars in the girders, are bent by hand with the aid of a special vise. For rods larger than ⅞ in. a machine designed for the purpose bends the rod to any angle and at the same time keeps all the bends in the same rod in a plane.

As usual in concrete building construction, the concrete was mixed on the ground and elevated to the floor where it was required. However, instead of following the more common practice of an elevator running in a frame which is raised from story to story as the building advances, an immense derrick with an 80-ft. boom was set on top of a tower consisting of a pyramidal frame of timber with its diagonal braces carefully bolted. The base of the derrick was thus 55 ft. above the ground and so high that buckets could be emptied upon the roof. This derrick was used not only for hoisting the concrete, but for raising the form timber and handling other material and tools. The arrangement of the derrick and tower is shown in the photograph, Fig. 3.

It was thought when the building was begun that it would be the best plan to dump the concrete from the bucket at various places on the floor where it was required, the boom being long enough to swing over a considerable area of the floor. This worked well in the lower stories, but for the upper floors and the roof, where the swing of the boom became limited, it was found more economical to dump the concrete into a hopper to be wheeled in barrows to place. Fig. 4, which is taken on the fifth floor, shows the operation of dumping the hoisting bucket into the hopper. By this plan less time was consumed in placing the bucket, and no tag-rope man was required, as the engineman could swing the boom to a certain point on the wall which brought the bucket directly over the hopper.

The concrete is composed of Portland cement, sand and broken stone in proportions 1:2:4. The sand and broken stone were stored in bins within less than 50 ft. of the mixer, and wheeled in barrows, which were also used for measuring, along an elevated run to a No. 5 Smith mixer. From the mixer the concrete fell into the derrick bucket which rested on an iron truck on wheels, about twice the length of the bucket, so that the empty bucket could be set by the derrick on one end of the truck while the other bucket was being filled, and then as soon as the full bucket was removed, the truck was pushed by the attendant to bring the empty bucket under the mixer.

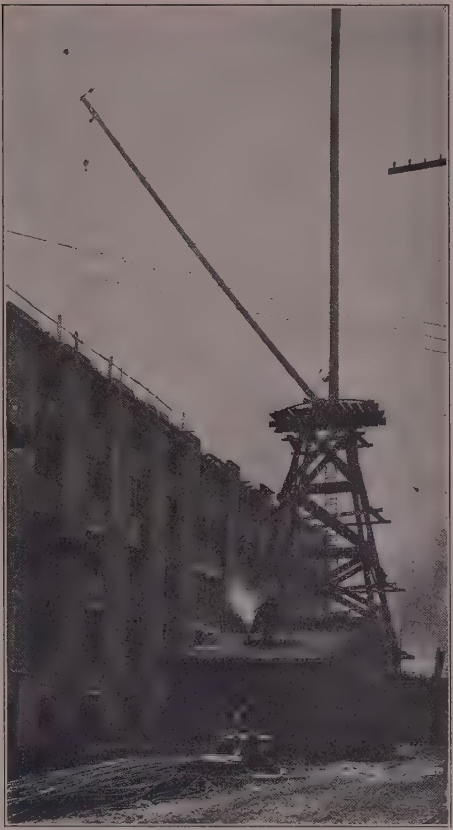


Fig. 3: Derrick for Hoisting Concrete.

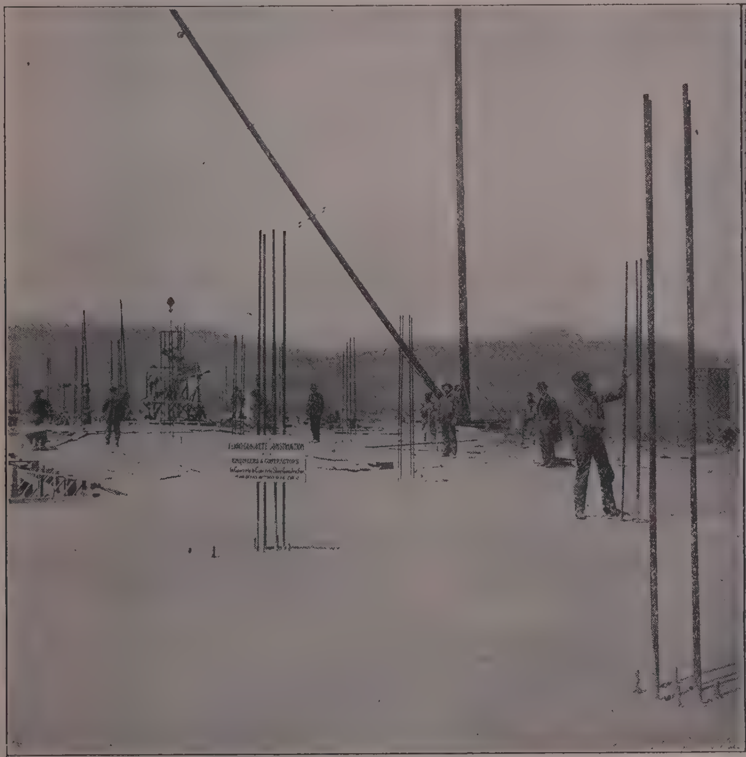


Fig. 4. Projection of Column Rods Above Floors.

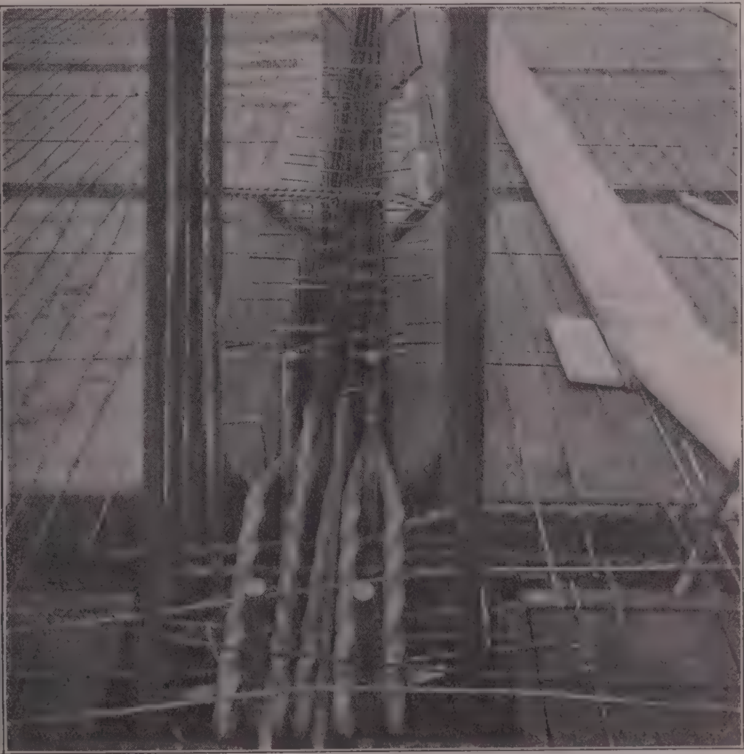


Fig. 5. Forms and Reinforcement For Girders and Slabs.

The steel in the columns, consisting generally of vertical round rods with hoops placed around them every foot in height, was set as soon as the concrete of any floor was laid, the column forms were built around it, and the floor slab and girder forms placed and carefully supported and braced by vertical struts and diagonals. The forms were thus built and the steel placed in the beams and slabs so that the concrete was poured in one-half of the floor while the forms were being built for the other half of the story.

The concrete was mixed wet enough to pour into the columns and a very fine face was obtained on the sides of the posts by the use of long-handled wooden paddles. The thickness of the floor slabs were gauged by 1x2-in. wood strips with blocks nailed on the under side of them at occasional intervals to bring the top of the strip to the required surface level. These were placed crosswise of the floor about every 15 ft. and the concrete poured between them, and screened with a long straight edge. The strips were immediately removed, and their location filled with concrete by men wearing rubber boots who walked through the soft material. As soon as the concrete was sufficiently set, the surface finish was spread and finally floated

The rate of speed on the building was a halt story per week.

Design.—The general floor plan is shown in Fig. 2. Fig. 5 shows the forms and the steel in place for the 50-ft. span girders and the floor in the west end of the building. These girders are 14 in. wide and 36 in. deep, and the span is 50 ft. in the clear.

The under side of this same floor construction after completion and removal of the forms is illustrated in the photograph, Fig. 6. The surfaces of the girders and floors show the knots and other impressions from the lumber of the forms, but a close examination fails to detect any of the irregularities and stone pockets so often found in structures of this character.

In general, there were four principal rods in each beam and two of these were bent up diagonally so as to reach the top of the beam or to extend over the supports. Typical forms of these bent bars are shown in Fig. 7.

The live loads assumed in the design are as follows: First floor, lower section, 500 lb. per square foot; floors over 50-ft. span, 150 lb.; other floors, 200 lb.; roof, 100 lb. The girders are calculated for 80 per cent. of the live load. The columns take the total dead load, and also are assumed to carry the following percentages of the live load coming from the girders: On the roof, 100 per cent.; seventh floor, 100 per cent.; sixth floor, 90 per cent.; fifth floor, 80 per cent.; fourth floor, 70 per cent.; third floor, 60 per cent.; second floor, 50 per cent.; first floor, 50 per cent.

Typical column reinforcement adapted for different sectional dimensions is shown in Fig. 8. In general, the vertical rods, which are round, have a sectional area of about 1 to 2 per cent. of the cross section of the column. The size of the rods is reduced from story to story, ranging on an average from about 2 in. in the lower floors to ½ in. in the upper stories.

The foundations for the columns are reinforced, and as they are built in advance of the columns, short vertical rods about 3 ft. long are set into them, which project up about 2 ft. into the column. The lower ends of these "stubs" are set upon plates which hold them in position, and form a bearing upon the concrete.

For the columns at one end of the building an inverted beam foundation was required because the footings could not project beyond the building line. This foundation, supporting two columns, was heavily reinforced at the top with

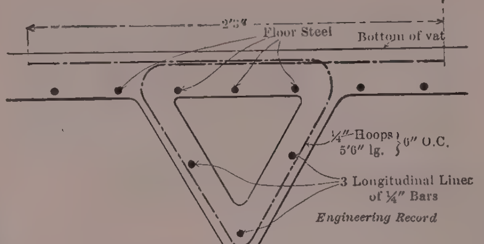


Fig. 11. Detail of Drain.

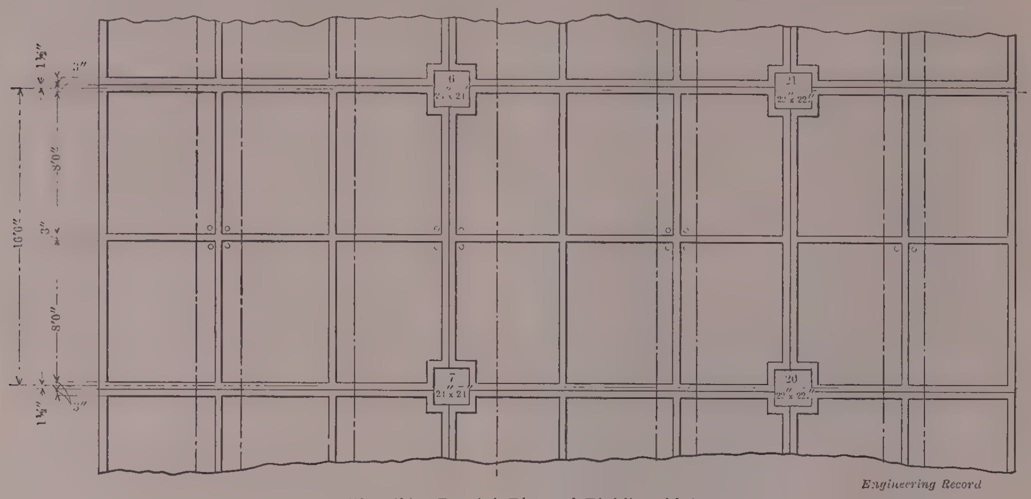


Fig. 11b, Partial Plan of Pickling Vats.

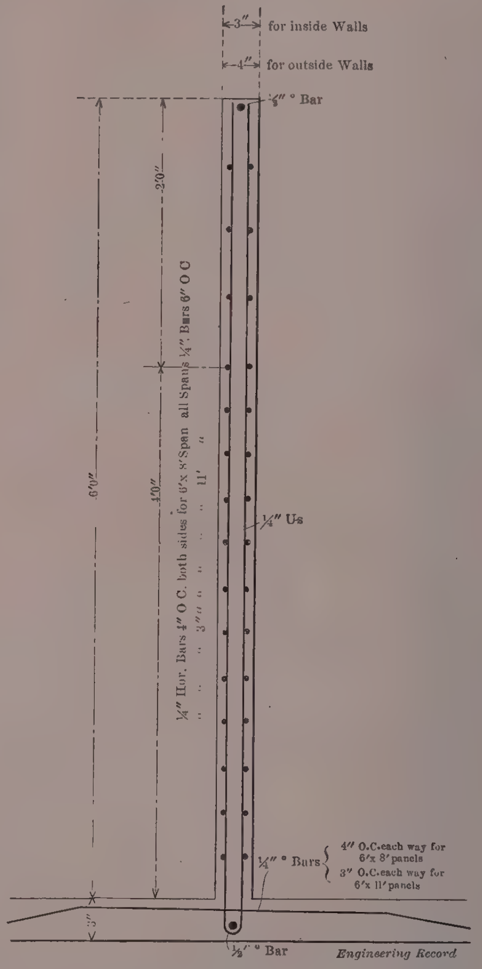

3" for inside Walls
4" for outside Walls
⅜" ⌀ Bar
2'0"
4'0"
6'0"
¼" Hor. Bars 4" O.C. both sides for 6'x 8' Span all Spans ¼" Bars 6" O.C.
¼" Us
¼" ⌀ Bars
4" O.C. each way for 6'x 8' panels
3" O.C. each way for 6'x 11' panels
3"
⅜" ⌀ Bar
Engineering Record

Fig. 11a. Section of Vat Walls.

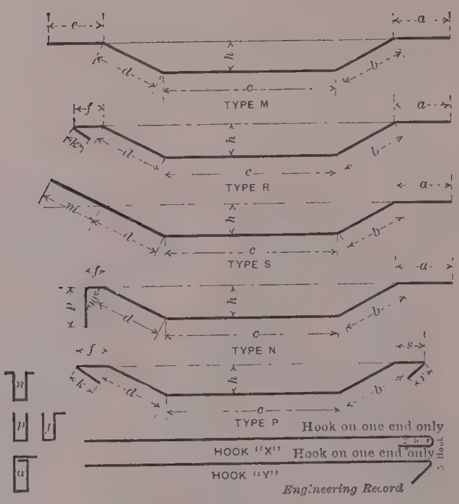


Fig. 7. Different Shapes of Bent Steel.

NOTE.—The contractors collect in one table and the above diagram all the data for the reinforcement of all beams and girders. For example, the beam *a* is shown in this table to have bent reinforcement of type R, of the dimensions tabulated, as well as straight bars and stirrups. This tabulation and diagram keep the floor plans free from lettering about details.

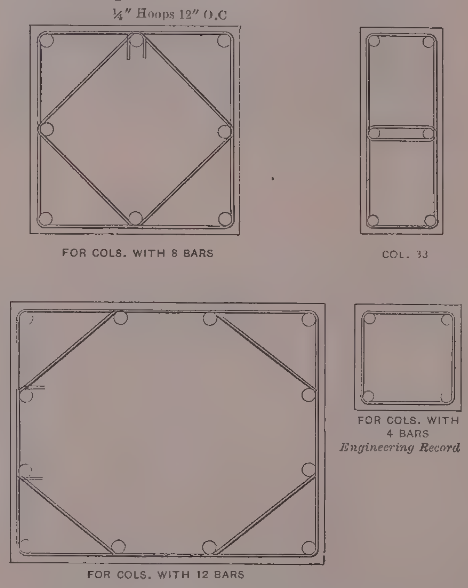


Fig. 8. Typical Column Reinforcement.

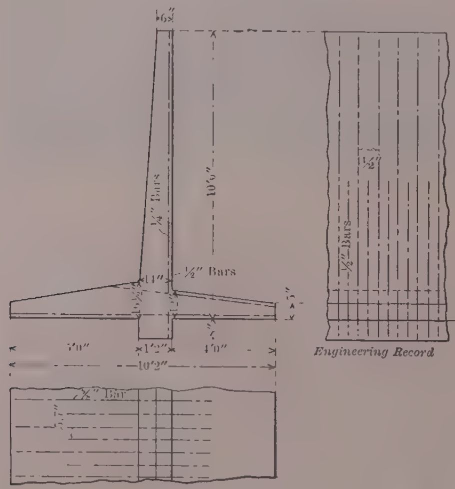


Fig. 10. Inside Retaining Wall.

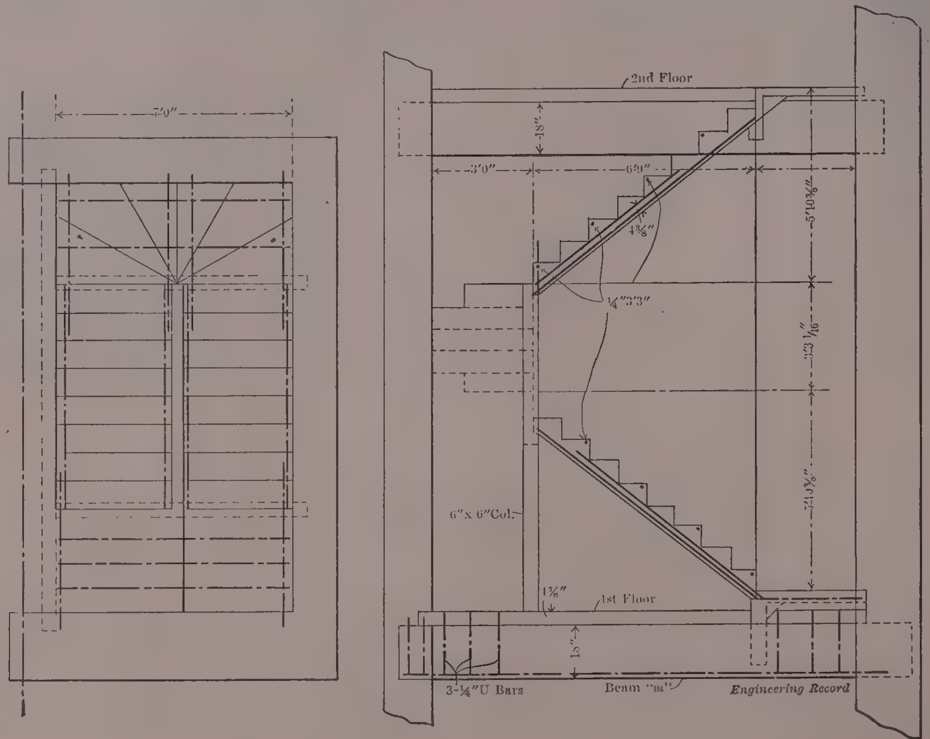


Fig. 9. Stairs from First to Second Floors, East Side.

sixteen ⅞-in. and 1-in. rods, and provided with stirrups as in ordinary beam construction.

The stairs which run up in the wings at each end of the building are generally in double flights with winders or platforms connecting them. They are usually enclosed on three sides by the brick wall of the building. The plan and elevation of one of the flights with winders is shown in Fig. 9. In the more usual pattern, with a platform at the half-story, no post is required.

The basement at one end of the building, shown at the right in Fig. 2, is about 10 ft. higher than the rest of the basement, and a concrete retaining wall, shown in Fig. 10, was therefore run across the building on the line of columns 12 and 15.

A large portion of the basement is occupied with tanks or vats for use in the leather processes. These pickling vats are each 8 ft. long, 6 ft. wide and 6 ft. deep, with walls only 2½ in. thick.

The plan of the vats in three of the bays running across the building is shown in Fig. 11, which also gives a section of a vat wall and of one of the drains below the vats. The photograph, Fig. 12, illustrates the appearance of the vats after completion. An inspection of the plans shows that the vats are built in groups, there being a group of six vats in each bay. Each group is built at one operation, so that there will be no joint, and the exterior walls of the group, that is, the walls on a line with the columns both ways, are thus double, but separated so as to permit shrinkage. The bottom of the vats are about 6 ft. above the ground, and they are supported by small columns at each intersection.

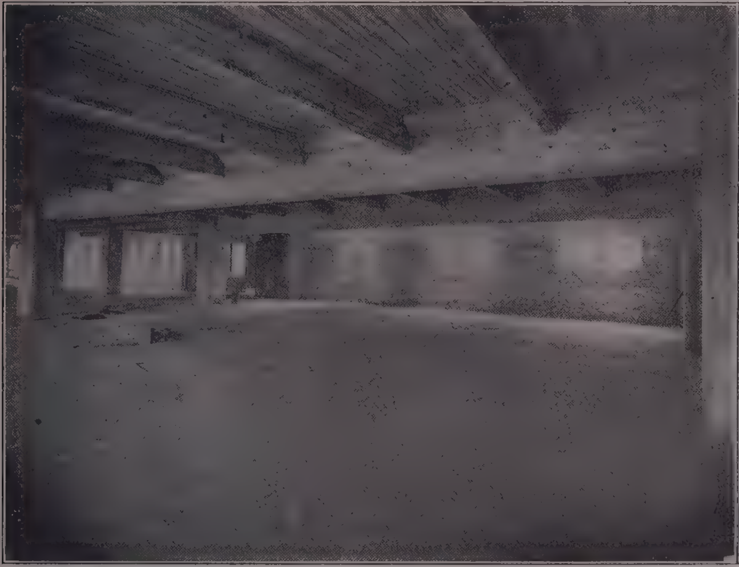


Fig. 6. Concrete Columns and Girders.

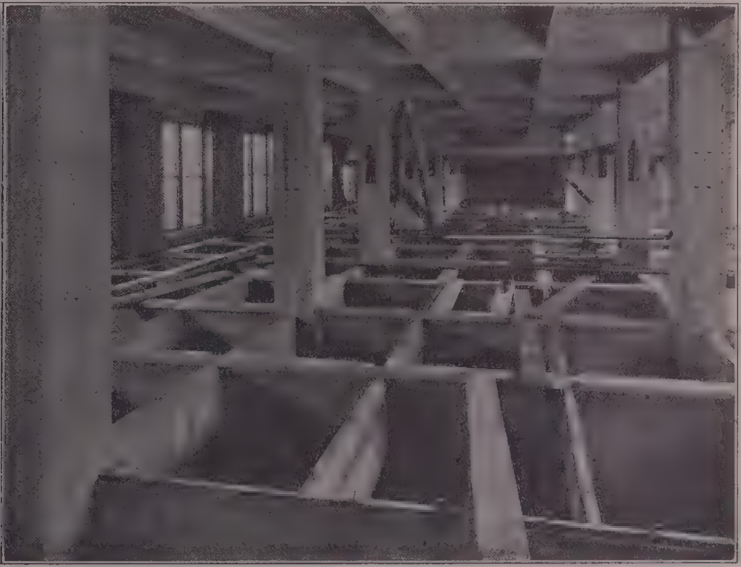


Fig. 12. Concrete Pickling Vats.

The troughs or drains which run under the vats are of unique construction. They are built as V-shaped troughs of mortar, 2 in. thick and 8 in. deep, reinforced with ¼-in. longitudinal rods and also with ¼-in. hoops which are allowed to project about 2 ft. above the sides when the trough is finished. The floors of the vats constitute the tops of these troughs. In some cases a thin oak veneer is sprung across the top of the drain to serve as a form for the concrete, and the floors of the vats are then spread over this and over the surface of floor between the drains, and the ends of the ¼-in. hoops which project above the sides of the drain are bent down into this floor so that the drains are in effect suspended from the floor and form a part of it. A section of the drain is shown in Fig. 11.

As is stated above, the walls of the building are of brick, but the water table, the sills and the caps of the windows and doors are formed of concrete laid in place. No mortar surface is given to them, but the aggregate is sand and rather fine broken stone, and care is used in placing it against the form.

After removing the forms, the surfaces are carefully dressed by polishing with a piece of sandstone so that they can scarcely be distinguished from cut stone trimmings.

The builders of the factory and the designers of the reinforced construction are the Ferro-Concrete Construction Co., of Cincinnati. The architect is Gustave W. Drach. C. W. Marx is consulting engineer.

Excavation of the West Neebish Channel, Near Sault Ste. Marie.

The improvement of the West Neebish channel of the Saint Mary's River has been undertaken by the United States government to increase the capacity of the connection between Lake Superior and Lake Huron which already exists in the river and canal. The traffic here is much greater than is generally known, amounting to 43,000,000 tons during the eight months of navigation in 1905. The river at this point has a bed of Niagara limestone with the usual horizontal stratification in which the improvement at the Rapids is known as the West Neebish channel. It is calculated that 1,800,000 cu. yds. of excavation will be required of which 1,600,000 yds. will be solid rock. It is estimated that four years are required for the execution of the work although at the present rate it would be completed many months sooner. The channel, 2¼ miles long, 22 ft. deep below extreme low water and 300 ft. wide, will be excavated with vertical sides in a maximum cut of 26 ft. which diminishes to 0 at both ends. The edges of the cut are surmounted by walls of cyclopean stone with the tops 6 ft. above low water, thus giving it a maximum height of 32 ft. at the ends of the cut.

The contract for the rock excavation at the rapids proper was awarded to the MacArthur Brothers Company, Chicago, and the unique method of work adopted by them was designed by Mr. A. F. MacArthur, general manager. The first step was to close the river by a temporary dam thrown across the river at a point as far upstream as the depth of the water permitted of economical construction, taking advantage of the numerous small islands that divided the shallow stream into a number of channels. After the upper temporary dam, the principal object of which was to stop the current, had been completed, a second, the lower temporary dam, was built, enclosing about a quarter of a mile of the channel to be excavated and of a width sufficient to permit the cableways to occupy this ground when this area should be unwatered. This area between the temporary dams was then unwatered and work by hand and temporarily installed machinery commenced and carried on pending the installation of the permanent plant.

Before the temporary dams were completed, in fact, as soon after the opening of the work as it could be arranged, the construction of the permanent dams, which are characteristic features of this work, was commenced. The upper permanent dam was commenced first, and practically the same method of construction was followed a little later on the lower permanent dam. This consisted of an earth embankment with side slopes of about 2:1, the base of which was built on the selected line of the dam by means of dump scows depositing material dredged from the channel where possible, outside of the dams. The top of the embankment was filled out by depositing material lightered by deck and pocket scows, from dredges at work in convenient places and from borrow-pits on shore. In the case of the upper dam this topping material was unloaded from the scows to the dam by hand and by means of a floating orange-peel dredge. After the bank had been strengthened by a continuation of this process till it had an elevation of 6 ft. above the water level and a top width of not less than 10 ft., the water side was rip-rapped with one-man size stone to prevent erosion by wave action.

In the fall, before much freezing takes place, which in this region is preceded by a considerable snowfall, the dams are thoroughly covered with brush, fastened down with wire and stones, which catch and hold sufficient snow to prevent serious freezing of the ground beneath. It is believed that if the dam above the water level freezes, there will be a plane of cleavage introduced which would assist the entrance of water, and the possible destruction of the dam. The upper dam, 1,900 ft. long, built in 18 ft. of water, has successfully performed its duty for fourteen months without any indication of weakening.

The lower permanent dam was nearly completed last winter by topping out the embankment through the ice from a convenient borrow-pit on shore, and later in the spring was finished with material brought by a track and dump cars from the same pit. The maximum depth of water at the site of this dam was 26 ft., its length is 2,600 ft., top width about 15 ft. and height above water, 5 ft. Otherwise it is of the same material and has been treated in the same manner as the upper dam and although the present winter is its first there is little apprehension felt as to its resistance.

Sixty-five Ton Traction Shovel with Stone Exceeding Three Cubic Yards in Dipper.

The material used in the construction of these dams was clay, gravel and boulders as it came from the bottom of the river by dredging, except the top which was sandy clay with some gravel and boulders from borrow pits on shore.

In the winter a gang is employed in cutting a relief gap in the ice in front of the dam to prevent the thrust of ice doing any damage to its rip-rap or crest.

The upper basin, the area between the crest of the rapids and the upper dam, was unwatered by two 12-in. centrifugal pumps and the lower basin by one 12-in. and one 18-in. centrifugal pump, since which time, notwithstanding this area is a river-bed, a 12-in. pump at each dam, working half-time has been able to keep the work so dry that water has to be pumped to the drills.

At the north end of the channel the contract requires that the approximately level surface of the rock shall be filled with the excavated material to a depth of 6 ft. for a distance of 300 ft. from the east side of the cut and for a distance of 50 ft. from the west side. At the south end of the cut one of the summer residences on the east side has rights for a steamboat wharf and channel close to the cut so that the government fill of 6 ft. is here limited to a very narrow strip on the east side of the river and there is no room for a large spoil bank at this place. It was necessary to deposit nearly 100 cu. yds. of spoil per lin. ft. of excavation on the east bank at the north end of the cut to make the 6-ft. fill, and as this material could be most conveniently dumped at the head tower end of the cableway, it was advantageous to locate the head tower on this side of the cut and to remove it enough farther from the cut so that there would be room left between the edge of the cut and the tower track to deposit between it and the required fill all of the spoil remaining except enough to make a fill 6 ft. deep and 50 ft. wide on the west bank of the cut.

In accordance with these considerations one pier of the cableways was designed by Mr. Frank B. Knight with a span of 1,100 ft. with the tail tower 201½ ft. over all from the west side of the cut, thus leaving a clear space of about 40 ft. between it and the edge of the fill required by the government. On the east side the head tower is about 760 ft. over all from the edge of the cut, allowing space between it and the 300-ft. government fill 6 ft. high for a spoil bank with a cross sectional area of 2,700 sq. ft. These two cableways were started at station 550, where the depth of the cut is a maximum, and will move north to the end of the work. At the same point two other cableways of 800 ft. span were started to move southward and are arranged with their tail towers on the east side of the cut and close to it while the head towers on the west side are about 450 ft. in the clear from the edge of the cut leaving ample space there for a 6-ft. fill about 60 ft. wide required there by the government and for a spoil bank with a cross section of 11,241 sq. ft. between it and the tower.

View Downstream Over the West Neebish Channel Cut.

A 6-ft. fill over 100 ft. wide is also required on the east side of the cut at the south end and it will be made by dumping a sufficient quantity of spoil in the narrow space between the tail tower and the cut. This spoil will at first form a bank considerably more than 6 ft. high which will be leveled off to the required uniform height after the tail tower has passed and its tracks have been removed. In the calculation of the cableway spans and arrangements of their tracks it has been estimated that the rock in the skips and buckets will occupy about 1.8 times the space it occupied in place and that in the spoil banks it will be somewhat compacted and will only occupy 1.6 times the space it occupied in place.

As this cut is obviously comparable in magnitude and character with that of the rock sections of the Chicago drainage canal it is of interest to note that in the latter case the cableways averaged about 700 ft. span with towers generally 73 or 93 ft. in height. These cableways, however, have all of their towers 103 ft. high with bases of the same size as those of the drainage canal. All of their other dimensions, however, as well as their capacities are about 50 per cent. larger than those for the former work.

In each cableway tower the inclined main posts are made with 12x12-in. timbers spliced and each face is divided by horizontal 4x12-in. braces into panels from 12 to 14½ ft. high which are X-braced with 4x12-in. diagonals, all of the connections being secured with ¾-in. bolts. Each tower has 36 wheels traveling on five lines of rails arranged to make standard gauge tracks 38 ft. 8 in. apart on centers under the tower. The three rails forming the track under the ballast boxes are 49½ ft. on centers from the outer tower track. The base of the tower is about 107 ft. long over all.

The main cable is a patent locked steel rope of 212 tons ultimate strength and has a diameter of 2¼ in., the largest size made. The carriage and hoisting tackle are operated by a Lidgerwood engine with two 12¼-in. diameter cylinders and 15-in. stroke. It has double drums 60-in. in dameter and uses compressed air at from 90 to 100 lbs. pressure. Each cableway is operated by one engine man, one signal man, and three men to hook on buckets, besides which the four cableways together require two riggers and a small track gang.

The excavation is made with vertical channeled sides in two lifts of approximately equal height. The spoil from the first lift is handled by one of each pair of cableways which is closely followed by the other cableway of the same span removing the spoil from the lower lift. The rock is removed in 8x8-ft. steel skips 30-in. deep which have a capacity of 2½ yds. of rock in place and were manufactured by Heggie Bros., Joliet, Ill. They are hoisted at a speed of 300 ft. per minute and are traversed at a speed of 12 to 1,500 ft. to the spoil banks where they are emptied by an aerial dump operated by the engine man in the head tower. On one cableway the carriage has made in 10 hrs. 251 trips carrying an average of 2¾ cu. yds. at each trip, making a total of 690 yds. of rock transported from the cut to the spoil bank in a single day. It is therefore considered a reasonable estimate that under favorable conditions with no delay for loading or waiting each cableway could maintain a delivery of from 700 to 800 cu. yds. of rock in place in 10 hours.

A notable innovation of rock excavation methods is the use of the steam shovels to handle the rock as shattered at the working face and loaded directly into the cableway skips. These steam shovels being mounted on traction wheels with tires 30 in. wide are independent of track laying and can readily follow the receding face of the excavation, moving along as the spoil is cleared up without waiting for new tracks to be laid. Their powerful 2½-yd. dippers, having the ability to engage the corners of large pieces of rock, are able to frequently place 3 or 5-yd. pieces in the cableway skip, thus saving a large amount of block blasting and increasing the rapidity of loading. The shovels which are used for loading the skips on three of the four cableways have demonstrated great economy of cost as well as increased capacity over the usual method of mucking the material by hand. No labor is required for them except that of the shovel crews and it is an astonishing fact that one shovel can load more material into the skips than a gang of 60 men previously loaded into them by hand. The cableways have proved amply competent to remove all of the material that the shovel can load, and it has been stated on good authority that this plant has made a new record in canal construction and rock excavation.

The equipment on this work includes a 1,000-h.-p. Ingersoll-Rand compressor plant, with the necesary pipe lines, operating two Lidgerwood cableways of 800-ft. span each, traveling southward, and two of 1,100-ft. span going northward, four channellers, of Ingersoll-Rand and Sullivan Machinery Co.'s make, a sufficient number of drills, pit pumps, etc. Besides the two pumps at the dams, the three 65-ton Marion shovels mounted on traction gear with tires 30 in. wide, are operated by steam. One of these shovels has handled over 1,000 cu. yds. of rock a day of two 10-hour shifts and maintained that rate for 25 successive days.

The removal of the material outside of the dams is being done with Edward Brothers' new dredge "Majestic." The work inside the dams is being done for and under the supervision of MacArthur Brothers Co., by the firm of Grant Smith & Co., of which, a member, Mr. C. H. Locher, is the manager at West Neebish and personally supervises the installation, the operation of the plant and the prosecution of the work. It is owing to his experience and the application of the cableway, his favorite system, in conjunction with the use of steam shovels, that the work has been so successfully prosecuted.

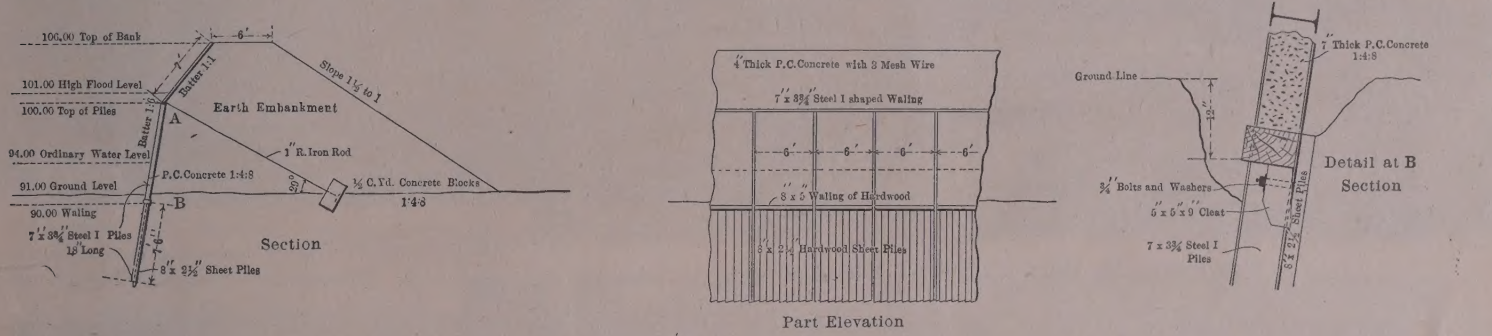
The Cost of Power from the plant of the Chicago Drainage Canal, at Lockport, described in The Engineering Record of Feb. 17, has been fixed at $26.40 per horse-power year for 24-hour service, and $20 for 12-hour service. This is the cost at the substation at West Forty-eighth Ave., Chicago, and all charges for transmission beyond that point must be borne by the purchaser.

Works for the Control of the Wag Water River.

By J. Monk Fletcher.

On the north side of the island of Jamaica are many comparatively large rivers which, during the rainy seasons, attain considerable volume and, having a rapid fall, flow with great velocity after a heavy rain, causing constant erosion of the banks and rendering necessary controlling works from time to time. The Wag Water River in dry weather is a small stream, but after heavy rain has fallen for a few hours in the hilly country through which the stream flows, it becomes a dangerous, rapidly flowing river ¼ to ½ a mile wide and of considerable depth. For the last two miles of its course the river flows through a wide plain composed of alluvial deposit, and in former years it has frequently changed its course through this plain.

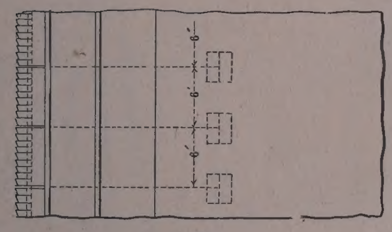
The railway connecting the south side of the island with the northeastern coast is carried across the plain on an embankment which crosses an old course of the river, and the junction road from the metropolis, Kingston, to the north side of the island, runs for some distance alongside the right bank of the river. The latter is crossed near its mouth by a steel trussed bridge consisting of two 130-ft. spans and one 180-ft. span, carried on concrete abutments and piers built on caisson-sunk concrete foundations carried well down below the bed of the river. This bridge carries both the railroad and an important main road along the north coast of the island.



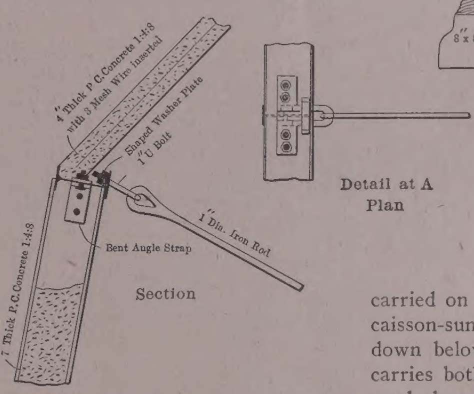
Section

Part Elevation

Detail at B Section

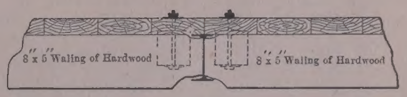


Part Plan


4" Thick P.C. Concrete 1:4:8 with 3 Mesh Wire inserted
Shaped Washer Plate
1" U Bolt
1" Dia. Iron Rod
Bent Angle Strap
7" Thick P.C. Concrete 1:4:8

Section

Detail at A Plan



Detail at B Plan

The Wag Water Groin.

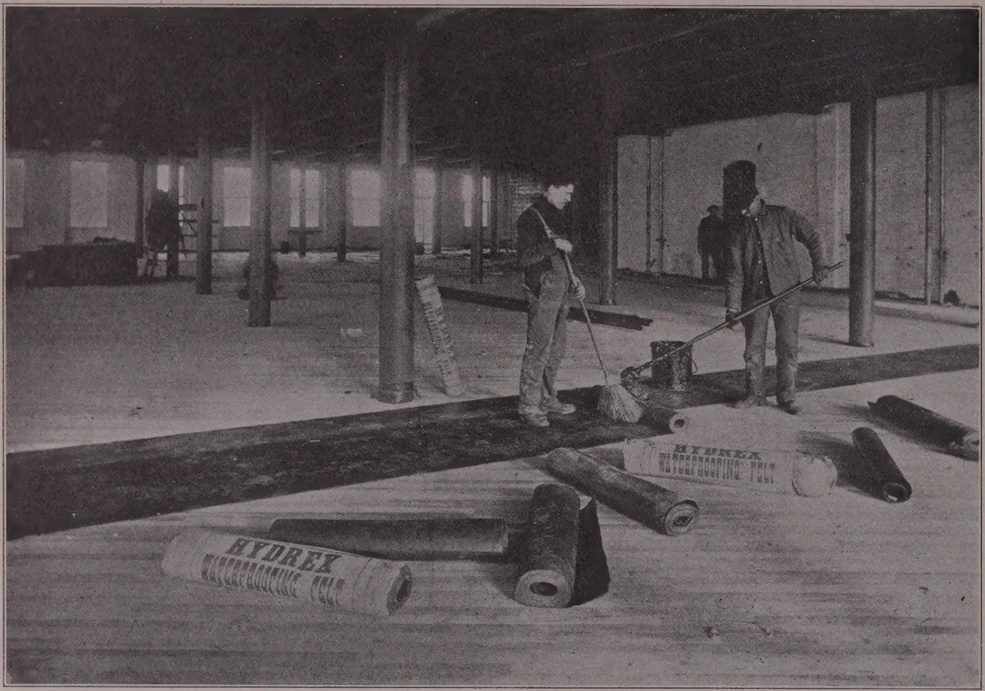
For some years the river has been gradually changing its course, threatening to break away towards the old course, mentioned above, leaving the bridge high and dry and destroying the embankment which carries the railway. Many deviations of the main junction road have been made, but the river still continued to erode its right bank and to approach the old channel.

Small groins of various kinds have been constructed from time to time, but these have been carried away and failed to keep the river to its course. The river had changed its course to such an extent that it at last flowed for some distance across the practically level plain almost parallel to and at no great distance from the railway embankment and was within a few chains of the old course before mentioned. This constituted an immediate and serious danger, rendering control works of magnitude absolutely necessary to confine the water to the channel under the bridge and preserve the railway embankment running across the plain.

Upon the left bank of the river is a low range of hills running parallel with its course and continuing as far as the bridge, the left abutment of which is built against the foot of these hills. At one time the river evidently ran close to the foot of these hills, and an old channel still remained into which the river overflowed when in flood.

On the right bank and about one mile above the bridge is a rocky spur of a range of hills running roughly at right angles to the range of hills mentioned above. After passing this point, which is known as "Jack's Rock," the river winds its devious course through the level plain to the sea, about two miles away. At Jack's Rock the river is confined to a space little wider than the width of the river when in flood.

It was decided that a proper and sufficient control of the river would be obtained by the construction at this point of a training wall of sufficient length and strength and at a suitable angle to direct the river through a short artificial cutting into the old channel at the foot of the hills on the left bank, which it is expected it will follow to and through the bridge. This training wall and the short artificial cutting have now been completed, and as far as can be seen the control of the river is established.

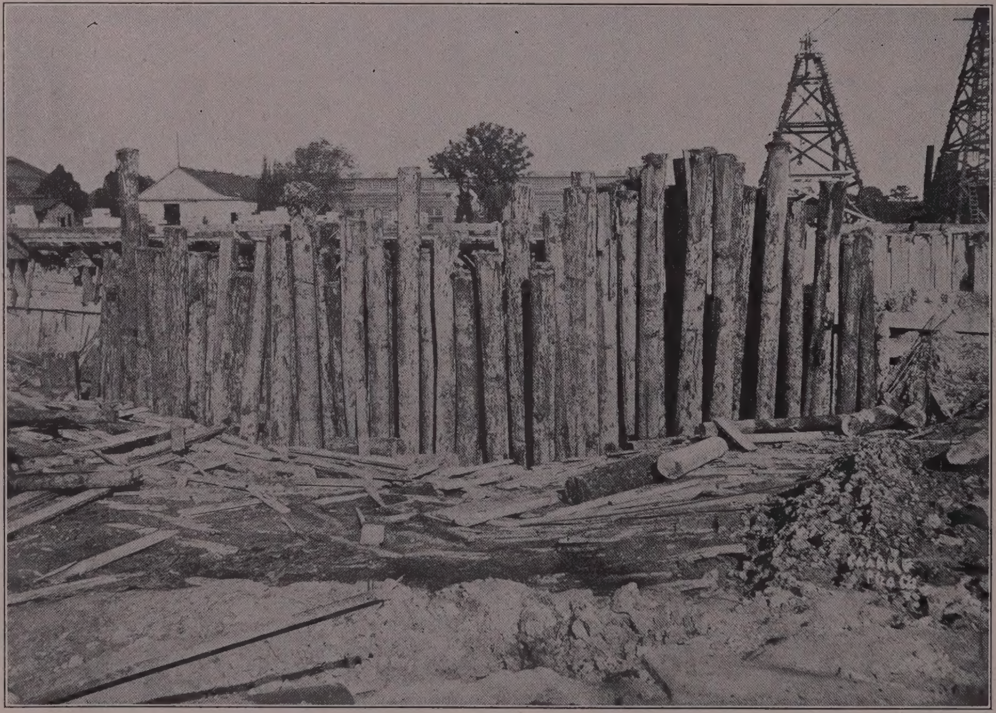


Waterproofing the Floors of a Brooklyn Printing Office.

The training wall is 990 ft. in length and is constructed of earth supported and protected on the river face by a Portland cement concrete panelling 7 in. thick between 7x4-in. rolled steel I-beams driven as piles 6 ft. apart between centers along the line of the wall.

The piles are 18 ft. long and are driven 7 ft. 6 in. below the bed of the river, with a batter on the face of 1 in 6. Each pile is anchored back to a ½ cu. yd. block of concrete, buried in the ground under the embankment, by a 1-in. round iron rod. A 7x4-in. steel I-beam is fixed upon the heads of the steel piles as a waling and secured by bolts and plates, as shown in the details. Between the piles, at a depth of 3 ft. 6 in. below low water level, native hardwood waling pieces are fixed, against which native hardwood sheet piles are driven along the whole length of the groin to a depth of 7 ft. 6 in. below the bed of the river. The heads of the steel piles rest against and support the hardwood walings and are level with the top side of the walings. This sheet piling is intended to prevent any scouring by the river under the concrete panelling.

The cement concrete panels rest on the hardwood walings and are built between the flanges of the steel piles. The concrete is flush with the faces of the steel piles at back and front, and extends up to the steel waling on the top of the steel piles. The concrete is composed of clean river gravel and sand obtained from the bed of the river and Portland cement mixed in the proportion of one of cement to four of sand and eight of stones.



Method of Repairing Break at Culvert, Charleston Dry Dock.

A cross section and details are given showing the method of construction.

After the concrete was thoroughly set, the earthen embankment was filled in at the back; the material for this being obtained from the cutting which was made to connect the river with its old channel. The earthen embankment was carried up to a height of 5 ft. above the steel and concrete facing, with a top width of 3 ft. and side slopes of 1½ to 1.

The work was begun and completed during the dry season which, fortunately for the work, was an exceptionally long one, so no trouble was experienced from the river.

The steel piles and hardwood sheet piling were driven by ordinary pile machines worked by hand labor. Very little difficulty was experienced in driving the steel piles, but some trouble was experienced with the sheet piling through encountering boulders. About 35 tons of steel and wrough iron, 322 cu. yd. of concrete, 21,800 ft. B. M. of hardwood lumber were used, and 10,908 cu. yd. of material filled in the embankment. The total cost of the work completed is about $12,350.

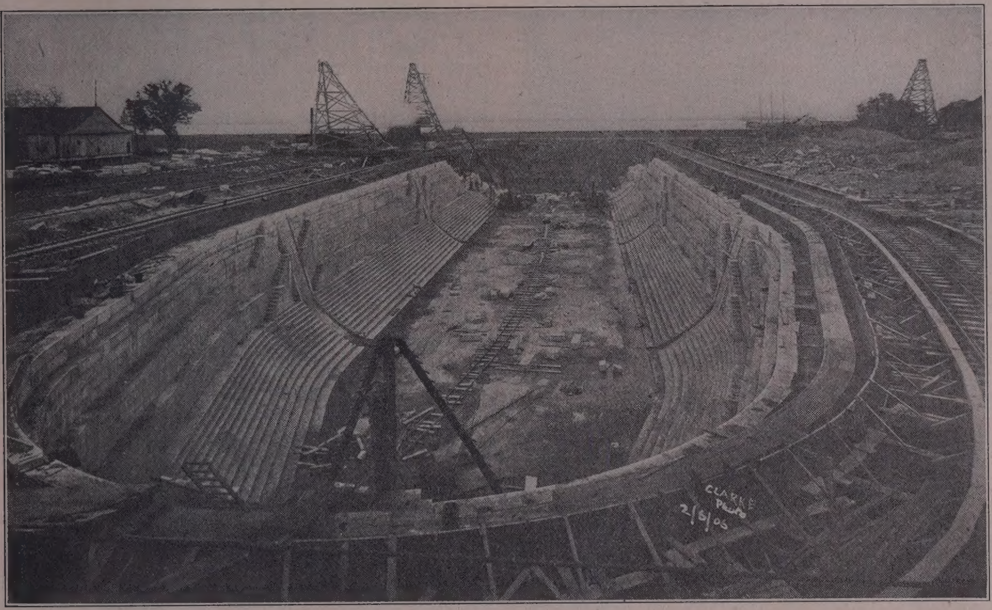
The designs for the work were prepared in the Public Works office in Kingston, under the direction of the Hon. V. G. Bell, C. M. G., the director of Public Works of the Colony, and the work was carried on by task and day labor under the management of Mr. D. L. Feurtardo, Superintendent of Public Works for the Parish of St. Mary.

Waterproofing a Printing Office Floor.

The accompanying illustration was taken during the process of waterproofing the floors of a large printing office in Brooklyn, and shows a new method of securing a low insurance rate. The use of waterproofing papers in floors of manufacturing and warehouse buildings of mill construction has long been practiced, but such construction does not meet the full requirements of the fire underwriters in cases where a large amount of valuable stock is carried which will be injured if water reaches it. The building in Brooklyn has six floors measuring approximately 72x120 ft. These were covered with two ply of Hydrex felt cemented together with Hydrex compound. In this system of waterproofing special attention is paid to the finish at the walls and columns, and in this case the waterproofing was turned up 2 in. around all such places, being protected at the angle by a small baseboard or wooden strip. The use of this system of waterproofing resulted in a reduction of 5 per cent. in the insurance rates in the building.

The Construction of the Charleston Dry Dock.

Dry Dock No. 1, at the Charleston, S. C., navy yard, a description of which appeared in The Engineering Record of March 4, 1905, is rapidly nearing completion. Bids for the caisson have been asked by the government, and it is proposed to add to the contract of the New York Continental Jewell Filtration Co., the pump well, the valve terminal of a double 36-in. syphon line extending through the north wall of the dock, and some extra crane track. The progress of the work was seriously hampered in May and June by a controversy over waterproofing material and in August by the addition of a double 36-in. pipe line embedded in the north wall; and in October by a slide of some 10,000 cu. yd. of mud. During the early part of last year Mr. F. J. Boas, 14 South Broad St., Philadelphia, Pa., on acount of stress of consulting and personal work, found it impossible to longer continue active supervision of the operation and the work has since been carried on by Mr. Henry M. Dougherty as engineer in charge.

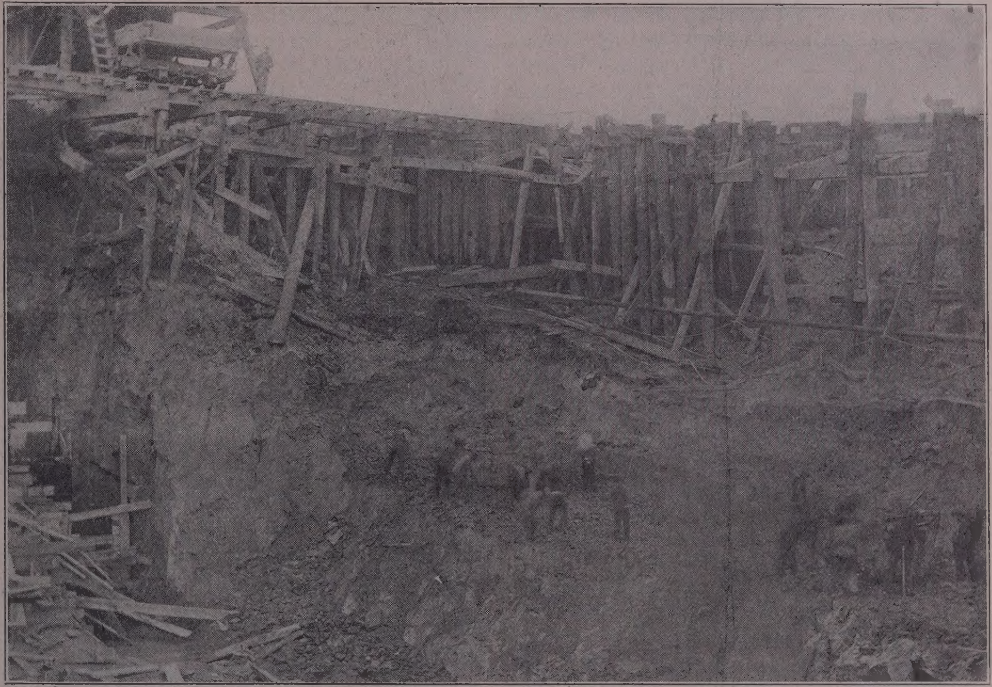


Present Condition of Charleston Dry Dock.

The average section of side wall excavation shows 34 ft. of wet and very mobile marsh mud, overlying 6 ft. of sandy clay, which in turn overlies marl. In many places there is a thin stratum of fine running sand between the marl and the sandy clay. The final foundation test on the marl gave a bearing power of 13 tons per square foot, and in order to remove this material expeditiously, it was found necessary to resort to blasting. The driving of the sheet piles and the supporting piles for the temporary falsework has made faults in the marl at an angle of about 45 deg. downward toward the floor of the dock, into which mud is washed by ground water and rains. There is thus an ever-present tendency for great masses of this material to slide, carrying with it the falsework supporting the sheeting and the construction tracks. This, coupled with the facts that the specifications require each 9-in. layer of concrete to be offset 3 ft., making it necessary to open comparatively long stretches, and that the work will not stand the expense of placing concrete under heavy timbering, presents a serious problem in the temporary support of the ground, which has been successfully dealt with, except in the instance above noted.

At the culvert which leads to the pump well, the interior falsework was, of necessity, largely omitted for a distance of 18 ft. At this point it was necessary to excavate to a depth of 44 ft. and a width of 13 ft., completely back to the sheet piling. This was timbered on 8-ft. vertical centers and 4 ft. horizontal centers of support; 12x12-in. pine range timber, 14x14-in. jack timber and 16-in. diameter pine struts (12 ft. long from ranger to jack timber and 25 ft. long trussed from jack timber to final support on concrete floor of dock) being used.

On Sept. 28 of last year the excavation had been nearly completed in the culvert and side wall and floor excavation had been completed to the end of the dock. There were several sheet piles broken in the driving which were all but uncovered in excavating. Ground water caused mud to wash through these broken sheet piles and the ground gave notice of breaking through the cracking of timbers at about 10 o'clock that night and at 11 o'clock, within 25 seconds after the last support had given away, 11,000 yd. of mud had flowed into the dock, making an aperture in the sheet piling 18 ft. wide and carrying with it 56 ft. longitudinally, of the interior falsework. The method of closing this break is shown in one of the accompanying photographs. To carry the construction track two 56-ft. wooden deck trusses were thrown across the break.



Extreme Outboard End of Work, Charleston Dry Dock.

A notable thing about the operation is that a 6-in. Knowles pump has always been able to take care of all water, even during extended periods of rain.

Even with the extra work which it is proposed to add to the contract and the delay attendant on obtaining material for it, there seems to be no doubt that the contractor will complete his work long before the government is prepared to make use of the dock.

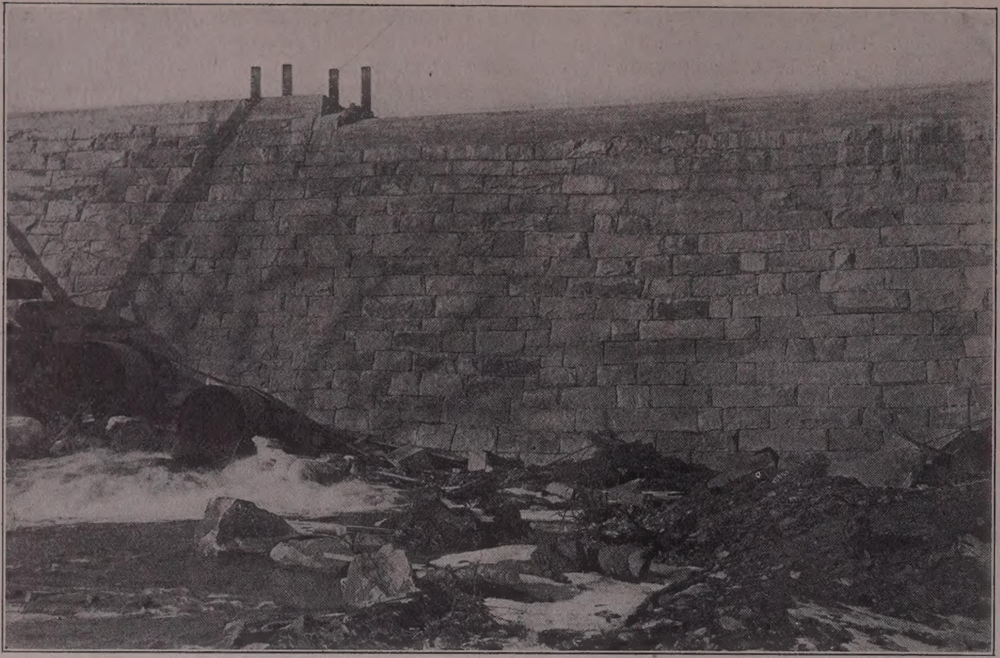
The Construction of the Alfred Dam.

What is said to be the largest masonry dam, and the highest dam of any kind in the State of Maine, has been recently completed by the Loring N. Farnum Co., 53 State St., Boston, Mass., for the Alfred Light & Power Co., at Alfred, Me. The owners are a subsidiary company of the Atlantic Shore Line Ry. Co., which owns and operates some thirty-five miles of standard gauge electric road for passenger and freight service, running from Sanford, Me., to Springvale, Cape Porpoise, and Biddeford. The road has at present a 2,200-h.-p. water power plant at Old Falls on the Mousam River and a steam auxiliary plant of 500 h.-p. at Kennebunk.

The new dam is situated on the Mousam River about one mile above the Old Falls plant, and about one-fourth of a mile from the line of the railroad. The valley at this point widens so that the dam is a comparatively long one and the pond formed has an area of some 500 acres with a length of five miles and an average depth of 18 ft.

The dam was built principally for storage purposes to maintain a constant flow at the Old Falls plant but the owners have arranged to install an 800-kw. plant at the new dam. Water for the new power house will be conveyed through an 8-ft. steel penstock about 150 ft. in length. There is also a waste tube 7 ft. in diameter which discharges into the stream immediately below the dam.

The dam is constructed of dry rubble which was quarried in the immediate vicinity, the downstream face being built with split stone, and the three lower and three upper courses being laid in Portland cement. The upstream face is covered with a 1:2:4 mixture of concrete 2 ft. thick, the concrete of the crest being 4 ft. thick and tapering again to 2 ft. thick at the downstream edge of the dam, as shown in the section.



Downstream Face of Dam Showing Dry Masonry

The total length of the dam is 995 ft. with a spillway of 580 ft. The height of the dam in the deepest part of the river is 39 ft. although at a point about midway on the dam, the rock bottom laid 11 ft. below the river-bed, making the height at that point, 50 ft. The abutments rise 3 ft. above the spillway. The gate frames and vertical racks are of steel. A single two-stemmed gate with heavy hoists covers each tube.

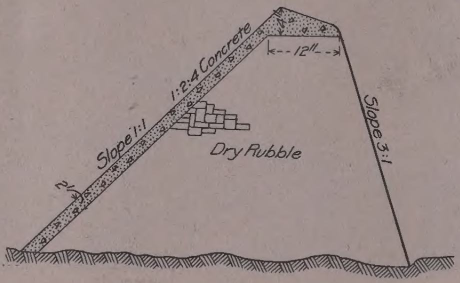
This work was pushed with all haste in order that it might be completed before spring, and Feb. 1 was set as time of completion. The Loring N. Farnum Co. signed the contract on Sept. 9; on Sept. 13 brush cutting was commenced, and the first derrick was erected on Sept. 19. Stone laying was begun on Sept. 28 and was entirely completed on Dec. 11. Concrete was all placed by Dec. 20 and the entire dam completed and accepted by the owners on Dec. 27, earning for the contractors a bonus of thirty-five days.

The following quantities were handled: Earth excavation, 4,173 cu. yd.; rock excavation, foundation, 50 yd.; dry rubble, 12,150 yd.; concrete, 2,790 yd.

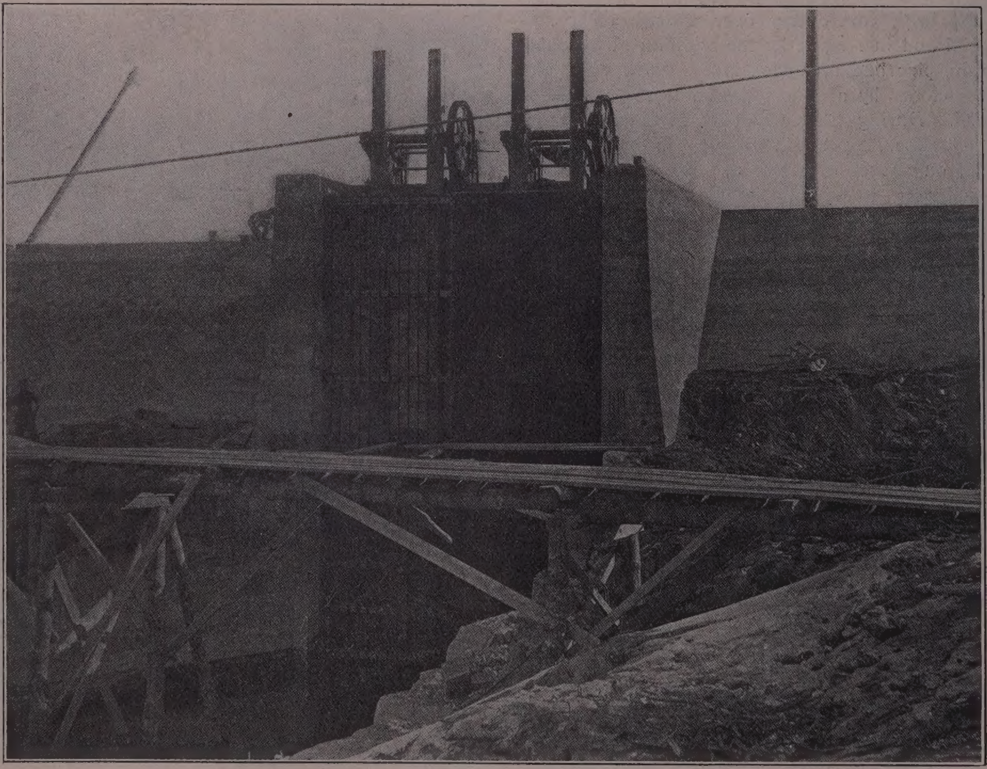
The contractor's plant included twelve steam derricks, eight of which were on the downstream face of the dam, all equipped with turning gears and bull wheels. The remaining four were distributed in four nearby quarries. The stone from two quarries was passed into the dam directly, while that from the other two was delivered by double-track railroads operated by gravity, the loaded car returning the empty.

Gravel was used in the concrete and was brought to the site of the dam by the electric road over a spur track which ran to the gravel bins situated on the west bank about 50 ft. upstream from the line of the dam. Here the contractors had a bin, elevator, and screen. The gravel was shoveled from the flat cars on to an incline platform which fed to the elevator that carried the gravel to the screen, where the sand was separated and dumped into one bin, the gravel of proper size into a second bin, and the large stones were carried on through the screen.

The cement shed was built on to the end of the bin and the concrete mixer set directly in front of, and a little below, these buildings. The gravel and sand were fed to the mixer through chutes from the bin, the cement was fed to the mixer by hand, and the finished concrete was dumped into a bucket on a small flat car directly under the mixer, and from there was carried to the dam on a narrow gauge railroad built on a trestle on the upstream face, and close to the dam the entire length.



Section of Alfred Dam



Concrete Upstream Face of Dam and Gates.

The laborers were all housed on the work, there being one shanty for the Italian laborers and another for white laborers; about 100 of the former, and 150 of the latter being used in the busy part of the construction.

The construction was begun on the east and west banks of the river at the same time. Just as soon as the penstocks, which are a little to one side of the main stream on the west bank, were set in place and the masonry built to a sufficient height, the stream was diverted through them by a cofferdam across the entire width of the river. In this manner the contractors were enabled to do the work without the aid of pumps, as there was sufficient fall in the river to drain the coffer area.

The Farnum Company has just accepted a contract to build a large concrete dam on the Saluda River at Greenville, S. C., where it has moved the plant and crew which were used on the above work.

Transporting Supplies from Railways to Site of Construction.

A method of transporting supplies that has never received the attention here which has been given it in other countries is the train of wide-tired trucks hauled by a traction engine. Such trains were employed extensively in the military operations in South Africa and Manchuria under more severe conditions than attend ordinary construction work and very little unfavorable criticism was passed on them. They are employed in lumbering operations in the West, and on the great wheat farms they are as common as sulky reapers in the East. Trucks have been specially designed for use in traction trains, and while they have been employed in this country mainly on highway construction they offer an atractive means of transportation for other materials. A stout traction engine, equipped with a winch and cable for helping itself out of difficult places, can be used on very rough roads.

Automobile wagons are employed considerably in Europe in handling supplies, but the slow development and high cost of such vehicles in the United States has debarred them from contractors' service up to the present time. Most of the foreign motor wagons are steam driven, for the large gasoline engines tried for trucking service have apparently been too easily thrown out of working condition by dirt and dust. There is no technical reason, however, why a good gasoline engine for contractors' wagons and launches should not be produced for sale at a comparatively low figure, as soon as the importance of great durability and resistance to shock rather than high speed is recognized.